

Bond University

DOCTORAL THESIS

Developing a simple tool for screening the health and motor performance-related fitness of children.

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Developing a simple tool for screening the health and motor performance-related fitness of children.

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MPhty, MEd(ECE), BExSc, BEd

*This thesis is submitted in total fulfilment of the requirements for the degree of
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Faculty of Health Sciences and Medicine

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Associate Supervisor: Professor, Dr Roger Hughes

ABSTRACT

The health and fitness of Australian children, including the onset of overweight and obesity, largely as a result of increasing sedentary behaviour, decreasing physical activity and poor dietary intake, can and will impact on Australia's future health, education, economic and social prosperity. It is therefore important to enhance opportunities for Australia's children to be physically active and as fit and as healthy as possible. Although much attention has been given to healthy eating and increasing physical activity in order to maintain or improve the health and wellbeing of Australian children, little attention has been given to motor proficiency as a determinant of physical activity in children. It is proposed that in order to curtail the current levels of child overweight and obesity, children must develop adequate motor proficiency and cardiorespiratory fitness, as these two attributes will likely enhance a child's ability to participate in age-appropriate physical activity. It is therefore essential to develop systems and tools that will identify early, those children who have poor health-related fitness with motor incompetency as a possible contributing factor. This thesis aimed to develop a simple tool for accurately screening the health and motor performance-related fitness of children to guide the referral process to physiotherapy for early intervention of motor incompetency. In doing so, the KidFit Screening Tool was developed using a number of methodological approaches, over three (3) stages.

The initial stage included a 'needs assessment' that started with understanding the literature around the impact of childhood overweight and obesity in Australian and global contexts, as well as determining the current and potential role of physiotherapists in preventing and dealing with this chronic condition. The review of the literature (Chapter 2) suggests that physiotherapists are skilled to deal with motor incompetence (a factor associated with overweight and obesity) but despite this, the national survey of Australian physiotherapists (Chapter 3) demonstrated little engagement by Physiotherapists with overweight or obese children for a number of

reasons that were predominantly related to individual workplace service models and policy (e.g. '*...not prioritized by service*'). The tools and outcome measures being used by physiotherapists were specifically investigated as part of this survey to help inform the development of the screening tool. Notably, less than half of Physiotherapists surveyed, assessed the motor skills of overweight and obese children and this was also attributed to the environment and service models where physiotherapists worked. This survey data provided insight into the reasons why physiotherapists were providing only limited services to overweight and obese children and these factors require consideration regarding the utility of the KidFit Screening Tool.

The second stage of this doctoral research involved the development of a pilot screening tool, which was based on the available literature regarding the health and motor performance-related fitness impairments of overweight and obese children. This pilot screening tool, along with a number of additional previously validated health and motor proficiency measures were used during data collection with a total of 260 children aged 5 to 17 years. The series of studies undertaken in this second stage of the doctoral research, explored the relationship between motor proficiency and health-related fitness measures and examined the psychometric properties of the newly designed measures within the KidFit Screening Tool. Prior to data collection a quality assurance step was undertaken to ensure that all persons collecting data (Physiotherapists and PE Teachers) were appropriately trained in taking each of the measures and the inter-tester reliability was assessed for each of the newly designed measures (Chapter 4). The absolute agreement between testers was very high (CA > 0.9) for each of the measures supporting the notion that adequately trained PE teachers and physiotherapists were appropriate to assist with data collection for this research and could potentially assist with screening the health and motor performance-related fitness of children on a larger scale. Chapter 5 examined the relationship between children's motor proficiency and health-related fitness to further inform the development of the KidFit Screening Tool. Significant predictive relationships ($r^2 > 0.6$, $p < 0.01$) were revealed between motor proficiency and BMI, waist

circumference and VO₂peak. These results indicate that motor proficiency should be a focus of investigation for children with poor health-related fitness. In Chapter 6 the concurrent and predictive validity of the Modified Shuttle Test-Paeds (MSTP) was investigated. A significant and strong correlation was found between VO₂peak and the MSTP ($r^2=0.749$, $p<0.001$) suggesting it is a valid measure of cardiorespiratory fitness with a high predictive validity for estimating VO₂peak in children. The MSTP was therefore included in the refined KidFit Screening Tool as a health-related fitness measure. In Chapter 7 the test-retest reliability and the concurrent validity of the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children was investigated. The SAMS had strong test-retest reliability (ICC=0.87) and strong predictive validity for determining gross-motor ability with overweight/obese children ($r^2=0.641$, $p=0.001$). Based on these psychometric properties, the SAMS was also included in the refined KidFit Screening Tool for feasibility testing.

The final stage of this doctoral research involved a modest feasibility study ($n=57$) to test the diagnostic accuracy of the KidFit Screening Tool for identifying children with and without health and motor performance-related fitness impairments (Chapter 8). The KidFit Screening Tool, uses designated cut-off values for the two measures included (i.e. the SAMS and the MSTP) and ROC analysis revealed moderate to high accuracy for identifying children with and without: overweight/obesity (AUC: 0.895); poor motor skills (AUC: 0.822) and poor cardiovascular fitness (AUC: 0.912). These results address the main aim of this PhD research program, providing an accurate screening tool that can be used by those who work with children to guide decisions regarding referral to specialised services for detailed investigation of motor proficiency as an underlying contributor to a child's poor health-related fitness. Future studies beyond this doctoral research are planned to develop normative data for the KidFit Screening Tool and to test its generalisability and utility to a wider population of Australian children and adolescents.

DECLARATION BY AUTHOR

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy. This thesis represents my own original work towards this research degree and contains no material which has been previously submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

I have clearly stated the contribution of others to my thesis as a whole, including statistical assistance, survey design, data analysis, significant technical procedures, professional editorial advice, and any other original work used or reported in my thesis. The content of my thesis is the result of work I have carried out since the commencement of my research higher degree candidature and does not include material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or institution of higher learning.

Nikki R Milne

PhD Candidate

Date: 18th December, 2014.

DECLARATION OF CONTRIBUTIONS TO CO-AUTHORED WORKS CONTAINED IN THE THESIS

All co-authors on the chapters/papers indicated below have approved these papers for inclusion in Nikki Milne's doctoral thesis.

Milne N., Low Choy N., Steele M. (2010) Development of a Tool for Screening Children with Overweight and Obesity: Inter Tester Reliability of Anthropometric and Motor Fitness Measures. *Obesity Research and Clinical Practice*, Vol 4, Supplement 1, 2010. S14, P26. (ISSN: 1871- 403X). Abstract Published.

Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing and submitting the abstract and poster. Low Choy (previous PhD supervisor) supervised the design and data collection for the study. Low Choy and Steele (Faculty statistician at the time) guided the analysis of data and reviewed the progressive drafts of the abstract and poster prior to presentation.

Milne N, Low Choy N, Leong GM, Hughes R, Hing W. (2014). Child obesity service provision: a cross sectional survey of physiotherapy practice trends and professional needs. *Australian Journal of Primary Health*. Full Paper Submitted.

Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Low Choy (previous PhD supervisor) supervised the design and data collection for the study. Low Choy, Leong, Hughes and Hing guided the analysis of data, reviewed the progressive drafts of the paper and provided detailed feedback.

Milne N, Leong GM, Hing W. (2014). The relationship between children's motor proficiency and health-related fitness. *Journal of Paediatrics and Child Health*. Full Paper Submitted.

Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Leong and Hing supervised the

design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Professor Nancy Low Choy (previous PhD supervisor) supervised the initial study design and Dr Michael Simmonds (Accredited Exercise Physiologist), assisted with the technical components of measuring peak oxygen uptake with participants.

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Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Simmonds and Hing supervised the design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Associate Professor Elaine Beller and Dr Robin Orr provided advice regarding the statistical analysis of data.

Milne N, Hing W. (2015). Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children. *Journal of Australian Strength and Conditioning*. Full paper submitted.

Declaration: Milne was responsible for the design of the study, data collection, data analysis, writing, editing, and submitting the article. Hing supervised the design of the study, guided the data collection and analysis, reviewed the progressive drafts of the paper and provided detailed feedback. Associate Professor Elaine Beller, Dr Robin Orr and Dr Allan Abbott provided advice regarding the statistical analysis of data.

STATEMENT OF CONTRIBUTIONS BY OTHERS TO THE THESIS AS A WHOLE

Professor Nancy Low Choy (previous PhD supervisor) assisted in the original development of the research objectives, formulation of the research methodology and interpretation of the data for the survey of physiotherapists regarding child obesity practices.

Professor Roger Hughes, Associate Professor Gary Leong and Professor Wayne Hing (current PhD supervisors) have assisted with formulation of research methodology and interpretation of the data for subsequent studies within this research higher degree. These supervisors have also provided thesis guidance through review of the manuscript, editorial assistance and detailed comments and feedback.

Dr Michael Simmonds, assisted with supervising the design of one of the studies in this thesis document, assisted with the data collection and analysis of peak oxygen uptake for children in this study as an Accredited Exercise Physiologist and reviewed the progressive drafts of the manuscript for the related study, through to journal submission.

I as the PhD candidate developed the objectives, wrote the ethics applications, recruited the participants, conducted the research studies, conducted and interpreted the statistical analysis and wrote and edited the thesis following feedback from supervisors.

PUBLICATIONS AND CONFERENCE PRESENTATIONS

a) Publications

Abstracts:

1. **Milne N**, Low Choy N, Steele M. (2010) Development of a Tool for Screening Children with Overweight and Obesity: Inter Tester Reliability of Anthropometric and Motor Fitness Measures. *Obesity Research and Clinical Practice*, Vol 4, Supplement 1, 2010. S14, P26.
2. **Milne N**, Low Choy N, Leong G, Hing W and Hughes R. (2012) Physiotherapy and child obesity: Current trends in Australian practice. *Obesity Research and Clinical Practice*, Vol 6, Supplement 1, 2012. O044, P22. (<http://dx.doi.org?10.1016/j.orcp.2012.08.046>)

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1. **Milne N**, Low Choy N, Leong GM, Hughes R, Hing W. (2015). Child obesity service provision: a cross sectional survey of physiotherapy practice trends and professional needs. *Australian Journal of Primary Health*, 1-7. <http://dx.doi.org/10.1071/PY14101>.
2. **Milne N**, Leong GM, Hing W. (2015). The relationship between children's motor proficiency and health-related fitness. *Journal of Paediatrics and Child Health*. Full Paper Submitted.

3. **Milne N, Hing W. (2015).** Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children. *Journal of Australian Strength and Conditioning (Online)*, 23, (2), 6-14.

b) Conference presentations by the candidate directly related to this Thesis

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1. **Milne N, Low Choy N, Steele M. (2010).** Development of a Tool for Screening Children with Overweight and Obesity: Inter Tester Reliability of Anthropometric and Motor Fitness Measures. Saturday 23rd October, 2010. ANZOS – Australian and New Zealand Obesity Society Annual Scientific Meeting, Sydney, Australia. Presented Poster and 3 minute oral presentation.
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3. **Milne N, Low Choy N, Leong GM, Hing W, Hughes R. (2013).** Perceived training and professional development needs of Australian physiotherapists for working with overweight and obese children. Thursday 28th Nov, 2013. GCHMRC – Gold Coast Health and Medical Research Conference, Gold Coast, Australia.
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2. **Milne N**, Low Choy N, Leong G, Hing W, Hughes R. (2013). Perceived training and professional development needs of Australian physiotherapists for working with overweight and obese children. October, 2013. APA – Australian Physiotherapy Association National Conference, Melbourne, Australia. 15-minute oral presentation.

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**ADDITIONAL PUBLICATION BY THE AUTHOR RELEVANT TO THE THESIS
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a) Publications

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AUTHOR'S CONFIRMATORY STATEMENTS

The opinions expressed in this study are those of the author and do not necessarily reflect those of Bond University.

The National Statement of Ethical Conduct in Human Research (developed jointly by the National Health and Medical Research Council, Australian Research Council and the Australian Vice Chancellors Committee, March 2007) has been adhered to during the conduct of this research.

TABLE OF CONTENTS

Contents

ABSTRACT	ii
TABLE OF CONTENTS.....	xviii
LIST OF TABLES	xxii
LIST OF FIGURES	xxiv
LIST OF ABBREVIATIONS AND GLOSSARY OF TERMS	xxv
CHAPTER 1. INTRODUCTION	1
1.1 Background	1
1.2 Planned Processes for Screening Tool Development	4
1.2.1 Stage 1 – Needs Assessment	4
1.2.2 Stage 2 – Taking Action: Screening Tool Development	5
1.2.3 Stage 3 – Evaluating the Action (The KidFit Screening Tool)	7
1.3 Aims and Objectives of this Doctoral Research	9
1.4 Significance of this Doctoral Research	10
1.5 Thesis Presentation.....	10
CHAPTER 2. REVIEW OF THE LITERATURE.....	12
2.1 Introduction	12
2.2 Child Overweight and Obesity: Understanding the issue in Australian and global contexts.....	12
2.3 Definitions.....	13
2.4 Prevalence and Trends.....	14
2.5 Aetiology of overweight and obesity in children	15
2.6 Clinical health-related progressions and disability associated with overweight and obesity.....	21
2.7 The socio-economic burden of overweight and obesity	22
2.8 State and National priorities for the reduction of overweight and obesity in children and adults and the prevention of associated chronic disease.....	23
2.9 Intervention and management approaches to overweight and obese children and their families.....	24
2.10 The current role of Physiotherapist’s in working with overweight and obese children...	29
2.11 The need for new measures to be incorporated into the screening tool to guide the referral process for physiotherapy intervention	33

2.12	Selecting the measures for inclusion in the development of the screening tool	35
2.13	Health-related fitness measures.....	35
2.14	Motor Performance-related Fitness Measures	43
2.14.1	BOT2 – Gold Standard Reference Measure for Motor Performance-related Fitness .	45
2.14.2	Balance measures	48
2.14.3	Development of the Speed and Agility Motor Screen (SAMS) as a measure of Coordination, Speed, Agility and Balance.....	49
2.15	Screening Tests – Points for Consideration in Tool Development.....	50
2.16	Implications for Test Inclusion – the basis for a series of reliability and validity studies to support inclusion of measures in the KidFit Screening Tool.....	52

CHAPTER 3. CHILD OBESITY SERVICE PROVISION: A CROSS SECTIONAL SURVEY OF PHYSIOTHERAPY PRACTICE TRENDS AND PROFESSIONAL NEEDS

3.1	PRELUDE.....	53
3.2	ABSTRACT.....	54
3.3	SUMMARY STATEMENT	54
3.4	INTRODUCTION.....	55
3.5	METHODS.....	57
3.6	RESULTS	59
3.7	DISCUSSION.....	64
3.8	LIMITATIONS	67
3.9	CONCLUSIONS.....	67
3.10	REFERENCES.....	68

CHAPTER 4. DEVELOPMENT OF A TOOL FOR SCREENING THE HEALTH AND PERFORMANCE-RELATED FITNESS OF CHILDREN: INTER-TESTER RELIABILITY OF ANTHROPOMETRIC AND MOTOR FITNESS MEASURES

4.1	PRELUDE.....	69
4.2	ABSTRACT.....	70
4.3	INTRODUCTION.....	71
4.4	METHODS.....	73
4.5	RESULTS	74
4.6	DISCUSSION.....	75
4.7	LIMITATIONS	77
4.8	CONCLUSIONS.....	78
4.9	REFERENCES.....	78

CHAPTER 5. THE RELATIONSHIP BETWEEN CHILDREN’S MOTOR PROFICIENCY AND HEALTH-RELATED FITNESS	79
5.1 PRELUDE.....	79
5.2 ABSTRACT.....	80
5.3 SUMMARY STATEMENT	81
5.4 INTRODUCTION.....	81
5.5 METHODS.....	83
5.6 RESULTS	86
5.7 DISCUSSION.....	92
5.8 LIMITATIONS	94
5.9 CONCLUSIONS.....	94
5.10 REFERENCES	95
 CHAPTER 6. MODIFIED SHUTTLE TEST-PAEDS: A VALID CARDIORESPIRATORY FITNESS MEASURE FOR CHILDREN.....	 96
6.1 PRELUDE.....	96
6.2 ABSTRACT.....	97
6.3 INTRODUCTION.....	98
6.4 METHODS.....	99
6.5 RESULTS	103
6.6 DISCUSSION.....	109
6.7 LIMITATIONS	112
6.8 CONCLUSIONS.....	112
6.9 REFERENCES.....	113
 CHAPTER 7. VALIDATING THE SPEED AND AGILITY MOTOR SCREEN (SAMS) AS A MOTOR PERFORMANCE-RELATED FITNESS MEASURE FOR CHILDREN	 114
7.1 PRELUDE.....	114
7.2 ABSTRACT.....	115
7.3 INTRODUCTION.....	116
7.4 METHODS.....	118
7.5 RESULTS	122
7.6 DISCUSSION / LIMITATIONS.....	127
7.7 CONCLUSIONS.....	130
7.8 REFERENCES.....	130

CHAPTER 8. DIAGNOSTIC ACCURACY OF THE KIDFIT SCREENING TOOL FOR IDENTIFYING CHILDREN WITH AND WITHOUT HEALTH AND MOTOR PERFORMANCE-RELATED FITNESS IMPAIRMENTS: A FEASIBILITY STUDY.....	131
8.1 PRELUDE.....	131
8.2 ABSTRACT.....	132
8.3 INTRODUCTION.....	133
8.4 METHODS.....	135
8.5 RESULTS	140
8.6 DISCUSSION.....	144
8.7 LIMITATIONS	146
8.8 CONCLUSIONS.....	147
8.9 REFERENCES.....	148
 CHAPTER 9. DISCUSSION AND CONCLUSIONS	 149
9.1 DISCUSSION.....	149
9.2 STRENGTHS AND LIMITATIONS.....	154
9.3 SIGNIFICANCE OF THIS DOCTORAL RESEARCH AND FUTURE DIRECTIONS.....	156
9.4 CONCLUDING STATEMENT AND KEY FEATURES	159
 CHAPTER 10. REFERENCES	 160
 CHAPTER 11. APPENDICES.....	 188

LIST OF TABLES

Table 3.1 Characteristics of survey respondents.....	60
Table 3.2 Physiotherapy service provision to overweight and obese children.....	62
Table 4.1 Inter-tester reliability and absolute agreement between testers for anthropometric and motor performance-related fitness measures.....	75
Table 5.1 Health-related fitness characteristics of study participants in total group and 1st and 4th motor quartile groups.....	87
Table 5.2 Motor performance-related fitness characteristics of study participants...	88
Table 5.3 Pearson's correlations between motor proficiencies and health-related fitness measures.....	90
Table 5.4 Multiple regression coefficients between motor proficiency models and health-related fitness measures.....	91
Table 6.1. Physiological and anthropometric characteristics of study participants and correlations with cardiorespiratory fitness measures.....	104
Table 6.2 Cardiorespiratory fitness characteristics of study participants during incremental exercise testing and field tests.....	105
Table 6.3 Pearson's correlations (r) and regression coefficients (r^2) between VO_{2peak} (mL/kg/min) and alternative field tests for cardiorespiratory fitness.....	106
Table 7.1 Gross-motor scores and anthropometric characteristics of participants..	123

Table 7.2 Pearson correlations and linear regression coefficients between the Speed and Agility Motor Screen (SAMS) and Gross-Motor Performance variables of the Bruininks-Oseretsky Test of Motor Proficiency- 2nd Edition (BOT2).....	125
Table 8.1 Criteria applied for levels of evidence for a reasonable diagnostic screening measure using the Area Under the Curve (AUC).....	139
Table 8.2 Means and Standard Deviations for Health and Performance-related Fitness Measures.....	141
Table 8.3 Multiple Regression Coefficients (r^2) between the KidFit Screening Tool and BMI, VO_{2peak} and Motor Proficiency.....	142
Table 8.4 Diagnostic accuracy parameters of the KidFit Screening Tool.....	143
Table 8.5 Output from the Receiver Operating Curves (ROC) for determining the accuracy of the KidFit Screening Tool for identifying children with and without overweight or obesity, poor motor skills and/or poor cardiorespiratory fitness.....	144

LIST OF FIGURES

Figure 1.1 An overview of the research reported in this thesis and its relationship to the stages of development for the KidFit Screening Tool.....	8
Figure 2.1 Framework for factors associated with obesity and overweight.....	16
Figure 3.1 Suggested content area (themes) for inclusion in physiotherapy clinical practice guidelines for working with children who are overweight or obese.....	63
Figure 5.1 Waist Circumference and BMI for BOT2 Total Motor Proficiency quartile groups.....	92
Figure 6.1 Relationship of the MSTP to important parameters of cardiorespiratory fitness (VT1, VT2, VO ₂ peak).....	108
Figure 7.1 95% Limits of Agreement for the Speed and Agility Motor Screen (SAMS) 1st and 2nd Trials.....	124

LIST OF ABBREVIATIONS AND GLOSSARY OF TERMS

ABS – Australian Bureau of Statistics

AIHW – Australian Institute of Health and Welfare

ANOVA – Analysis of Variance statistic, for analysing between group means

AUC – Area Under the Curve (related to ROC Analysis)

APA – Australian Physiotherapy Association

APA NPG – Australian Physiotherapy Association, National Paediatric Group

BEEP Test – Australian version of the 20m Modified Shuttle Run Test

BMI – Body Mass Index

BMI Z – Body Mass Index (standard deviation from BMI for age)

BOTMP – Bruininks Oseretsky Test of Motor Proficiency

BOT2 – Bruininks Oseretsky Test of Motor Proficiency (2nd Edition)

BP – Blood Pressure

BUHREC – Bond University Human Research Ethics Committee

CA – Cronbach's Alpha statistic

CDC – Centres for Disease Control and Prevention

CI – Confidence Interval

Concurrent Validity – a statistical method to assist with defending the use of a test for predicting another outcome. Concurrent validity can be demonstrated when the test being examined, correlates highly with another measure that has previously been validated.

CRF – Cardiorespiratory Fitness

CV - Cardiovascular

CVD – Cardiovascular Disease

DCD – Developmental Coordination Disorder

Diagnostic Accuracy – a statistical method used to examine how well a measure discriminates between having and not having a condition.

DF – Degrees of Freedom

DXA – Dual Energy X-ray Absorptiometry

ECG - Electrocardiogram

ER – Efficiency Ratio

FFM – Fat Free Mass

FM – False Negative

FP – False Positive

GAS – Goal Attainment Scale

Go4Fun – NSW modified MEND Program go4fun@betterhealthcompany.org

GP – General Practitioner

HDL – High density lipoprotein

Health-related Fitness - Cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility

HPE teacher – Health and Physical Education teacher

HR – Heart Rate

HTWR – Height Weight Ratio

HW – hypertriglyceridemic waist

ICC – Intra-class Correlation Coefficient statistic

IMT – Intima-media thickness

Inter-tester Reliability – the degree of agreement between testers

IOTF – International Obesity Task Force

KidFit Screening Tool – A screening measure of exercise capacity made up of the MSTP and the SAMS

LDL – Low density lipoprotein

LR+ - Positive likelihood ratios

LR- - Negative likelihood ratios

MD Team – Multidisciplinary team

MEND – Mind, Exercise, Nutrition....Do it! <http://au.mendcentral.org>

MMT – Maastricht's Motor Test

MMT – Milne Motor Test (NOTE: The name of this test was changed to SAMS during the write up phase of this thesis).

MSTP – Modified Shuttle Test Paeds

NCDS – National Chronic Disease Strategy

NHMRC – National Health and Medical Research Council

NPG – National Paediatric Group (of the APA)

NSMDA – Neuro Sensory Motor Developmental Assessment

NSW – New South Wales

NVP – Negative Predictive Value

OT – Occupational Therapist

PA – Physical Activity

PACER – Progressive Aerobic Cardiovascular Endurance Run

PDAY – Pathobiological Determinants of Atherosclerosis in Youth Study

PDMS-2 – Peabody Developmental Motor Scale, 2nd Edition.

Performance-related Fitness - Balance, coordination, speed, agility and power, which all reflect the performance aspect of physical fitness

PE teacher – Physical Education teacher

Paediatric Physiotherapist – A physiotherapist who is specifically trained or experienced at working with children and families.

PPV – Positive Predictive Value

Predictive Validity – a statistical method used to assess the extent to which the result of a measure/test can predict the score or result on a criterion measure.

PT - Physiotherapist

QLD - Queensland

QOL – Quality of Life

RERpeak – peak respiratory exchange ratio

ROC Analysis – Analysis of the Receiver Operating Characteristic or ROC Curve. The ROC curve is analysed by plotting the true positive rate against the false positive rate at various threshold settings.

RSDP – Resting Diastolic Blood Pressure

RSBP – Resting Systolic Blood Pressure

SAMS – Speed and Agility Motor Screen

SCFE – Slipped Capital Femoral Epiphysis

SD – Standard Deviation

SE – Standard Error

SES – Socioeconomic status

SLS – Single leg stance

SLSEC – Single Leg Stance Eyes Closed

SLSEO – Single Leg Stance Eyes Open

SPSS – Statistical Package for the Social Sciences

SS – Standard Score (related to the BOT2)

T2DM – Type 2 diabetes mellitus

Test-retest Reliability – the consistency or variability in repeated measurements taken by a single person using the same instrument.

TP – True Positives

TPS – Total Point Score (relating to subtests within the BOT2)

TN – True Negative

ULFT – Upper Limb Flexibility Test

US – United States of America

VO₂ – Oxygen Consumption

VO₂max – Maximal Oxygen Consumption

VO₂peak – Peak Oxygen Consumption

VT – Ventilatory Threshold

VT1 – First Ventilatory Threshold: a marker of intensity where lactate begins to accumulate in the blood.

VT2 – Second Ventilatory Threshold: a marker of intensity where the lactate has quickly accumulated in the blood, where the person needs to breath heavily to compensate. Also known as the lactate threshold

WC – Waist Circumference

WC-IC – Waist Circumference measured at the iliac crest

WC-U – Waist Circumference measured at the umbilicus

WCPT – World Confederation for Physical Therapy

WHO – World Health Organisation

WHTR – Waist circumference to height ratio

20m MSRT – 20 metre Modified Shuttle Run Test

CHAPTER 1.

INTRODUCTION

1.1 BACKGROUND

Over recent decades, population wide surveys of children and adults have consistently indicated increased adiposity and decreased cardiorespiratory fitness (CRF) with approximately 25% of Australian children now reported to be overweight or obese with this figure remaining relatively stable since 2008 (Tomkinson, Leger, Olds & Carzola, 2003; Booth, Chey, Wake et al, 2003; Magarey, Daniels & Boulton, 2001; Department of Health, Australian Government, 2008). In addition, 63.4% of Australian adults are overweight or obese (Australian Bureau of Statistics – ABS, 2011). This high prevalence is of critical concern as there is well documented health and education related consequences of overweight and obesity (WHO, 1998; Dietz, 1998; Power, Lake & Cole, 1997; Castelli, Hillman, Buck & Erwin, 2007). These consequences are inclusive of obesity-related motor incompetence (Piek, Baynam & Barrett, 2006; Cantell, Crawford, Tish Doyle-Baker, 2008; Oakley, Booth & Chey, 2004) which impacts the capacity and subsequent likelihood of a child participating in physical activity (Smyth & Anderson, 2000). This has recently emerged as a factor to consider when planning referrals of overweight and obese children for assessment and intervention (National Health and Medical Research Council - NHMRC, 2013). As physiotherapists are skilled at assessing and improving children's motor proficiency (Chia & Choa, 2002; Schoemaker, Hijlkema & Kalverboer, 1994; Ketelaar, Vermeer, Hart et al, 2001), it is proposed that they could make a significant contribution to the management of children with poor health-related fitness (including those who are overweight or obese) if those who have underlying motor incompetence were correctly and efficiently referred for detailed assessment and intervention. Thus further exploration of these links between health and motor competence is required to inform the focus of this Thesis.

Weight status in young children has been shown to be an important predictor of weight status in early adulthood with the risk of overweight in early adulthood further increasing for children when parents' weight status is increased (Magarey, Daniels, Boulton & Cockington, 2003). Studies such as this, have led to the development of many hospital and community based interventions (Crowle & Turner, 2010) targeting the parents with a generic intervention rather than the child, in the hope of making family centred lifestyle changes to indirectly improve the health of the child. Programs which do target children directly are often generic in their approach to intervention offering the same program to every child of a similar age (e.g. MEND and Go4Fun; (Sacher, Kolotourou, Chadwick et al, 2010)). The generic nature of the programs means that individual determinants for a child being inactive or having poor health are not being assessed in detail and this may limit the success when it comes to measuring outcomes for some individuals.

Previous research has demonstrated a predictive relationship between motor proficiency and physical activity (Barnett, van Beurden, Morgan et al, 2009). Additionally, there is conclusive evidence that physical activity is a known determinant of healthy lifestyle and disease prevention in children (Hills, King & Armstrong, 2007) with sedentary behaviours associated with child overweight and obesity (Livingstone, Robson, Wallace et al, 2003; Strong, Malina, Blimkie et al, 2005). Although the environment is a known and strong determinant for a child participating in physical activity (Biddle, Gorely, Marshall et al, 2004), the above mentioned research highlights a need for early identification of children who do not possess adequate motor proficiency to access the environment, in a manner that is conducive to health promoting physical activity. Currently, there is no simple-to-apply tool or clear process that is aimed at early identification of such children, so that pre-emptive interventions can be instigated to prevent progression to poor health (e.g. obesity or poor cardiovascular fitness) or poor health advancing to chronic disease. A simple screening measure that could be applied by those who work with children in the

physical activity domain (e.g. PE teachers) could fill this gap. The screening measure could be applied when concerns exist regarding motor proficiency as a possible contributor to a child's poor health. The results of the screening tool could assist with directing appropriate lines of referral (e.g. paediatric physiotherapist or other suitably qualified professionals) for detailed assessment and intervention (as required) for those children who have motor incompetency as a potential contributing factor to their decreased physical activity or poor health (e.g. overweight/obesity or poor cardiovascular fitness).

Currently, a number of tools are used to screen and assess children for overweight and obesity with BMI percentiles (using BMI-for-age reference values) and BMI Z-scores proving to be the most commonly used for classifying overweight and obese children in Australia (NHMRC, 2013). These assessment tools are classification and prognostic based but do not guide the referral and therapeutic process and are not accepted measures for use in Queensland school environments. Furthermore, commonly utilised measures of cardio-respiratory fitness in schools (e.g. 20m MSRT/BEEP Test) can take over 20 minutes to complete, depending on group fitness levels and these tests obligate a 'drop-out' nature on completion, where the level of achievement is immediately obvious to a child's peers. Therefore, a measure which is shorter in duration and does not have a drop-out nature is warranted for screening the cardiorespiratory fitness of children in schools.

It was anticipated that the outcome of this PhD thesis would involve the development of a simple tool for screening the health and performance-related fitness of children and adolescents which when applied, will accurately identify children who are: overweight or obese; have reduced motor proficiency and/or; reduced cardiorespiratory fitness. This information could then be used to guide the referral process to physiotherapy (or other suitably qualified professionals) for detailed assessment and intervention. The need for such a screening tool (for a number of professions including Physiotherapy) has recently been highlighted by the State-wide

Child and Youth Clinical Network, Child Obesity Working Group established by Queensland Health. The development of this simple, valid, reliable and accurate screening tool was planned across three stages of this doctoral research (See Figure 1.1). A series of studies were undertaken during the three stages of screening tool development in order to meet the aims of the PhD research program. Figure 1.1 represents an overview of the research reported in this thesis and its relationship to the stages of screening tool development.

1.2 PLANNED PROCESSES FOR SCREENING TOOL DEVELOPMENT

The stages reported in Figure 1.1 have been undertaken during this PhD program to develop and refine the KidFit Screening Tool, which was the overarching objective of this doctoral research. Further detail for each stage of screening tool development is outlined below.

1.2.1 Stage 1 – Needs Assessment

- a. Identification of the problem and review of the existing literature* – an extensive review of relevant literature and research was undertaken (Chapter 2).
- b. Profile of existing physiotherapy tools and services for overweight and obese children and their families and understanding the perceived needs of physiotherapists in order to work with overweight and obese children.* – This step was completed with an extensive review of the literature (Chapter 2) and a national survey of Physiotherapists who service children in Australia (Chapter 3).
- c. Analysis and interpretation of the results* – this step assisted with developing a clearer perspective of the current service provision of physiotherapists to overweight and obese children and identification of their professional needs for working with overweight and obese children and their families (Chapter 3).

1.2.2 Stage 2 – Taking Action: Screening Tool Development

This involved developing a Data Collection Sheet, comprising of new measures to be included in the KidFit Screening Tool based on the existing literature and piloting the tool with other previously validated measures known to be associated with overweight and obesity, including a gold standard reference measure for motor proficiency; Bruininks Oseretsky Test of Motor Proficiency, 2nd Edition (BOT2). See Appendix 2 for a copy of the Data Collection Sheet used in the initial stages of this research program, which included the following information and measures:

1. Parent completed database / questionnaire – including Name, Age, DOB, Gender, reported Medical History, School. (Appendix 1)
2. Height, Weight to calculate BMI (as percentiles and Z-scores)
3. Waist circumference (umbilicus and iliac crest)
4. Heart Rate and Blood Pressure (pre and post testing)
5. Modified Shuttle Test – Paeds (MSTP): a newly designed measure of cardiorespiratory fitness for children
6. Bruininks Osteretsky Test of Motor Proficiency, 2nd Edition (BOT2) – complete test (Gold Standard Test of Motor Proficiency)
7. Speed and Agility Motor Screen (SAMS): a newly designed measure incorporating functional strength, whole body coordination, speed, agility and balance; a timed test while the child moves from standing with hands by side, to laying prone with hands above head and feet together, then rolling as a log 360 degrees, standing up and performing a two stage jumping jack (star jump)
8. Balance Tests – Single leg stance eyes open (SLSEO) and single leg stance eyes closed (SLSEC)
9. Flexibility Tests - Sit and Reach test + upper limb flexibility test (ULFT)

After designing the pilot KidFit Screening Tool based on the available literature, a number of additional steps were taken to ensure all examiners were suitably trained and reliable with taking the measures and to further examine the psychometric properties of the individual measures included in the KidFit Screening Tool. These included:

- a. ***A Quality Assurance step: Examining Inter-tester reliability*** of newly designed measures to be included in the KidFit Screening Tool and refining the measures and instructions for the measures. (Chapter 4).

During this study the newly developed items; Speed and Agility Motor Screen (SAMS), Modified Shuttle Test Paeds (MSTP) and the Upper Limb Flexibility Test (ULFT) were analysed and user feedback from the assessors were gathered to guide the decisions about the appropriateness and practicality of the items for use with children, particularly in school environments, and to improve the instructions for assessing the items. The instructions for children to perform the tasks were refined during this quality assurance step.

- b. ***Examining relationships between children's motor proficiency and health-related fitness***, to further inform the KidFit Screening Tool. (Chapter 5)
- c. ***Validating the newly designed Modified Shuttle Test-Paeds*** as a suitable cardiovascular fitness measure for children to be included in KidFit Screening Tool. (Chapter 6).

This study required the addition of 2 further reference measures; 20m MSRT and an incremental exercise test (treadmill) to establish VO_{2peak} .

- d. ***Examining the validity and test-retest reliability of the Speed and Agility Motor Screen (SAMS)*** as a motor performance-related fitness measure to be included in the KidFit Screening Tool. (Chapter 7)

These studies provided valuable data to assist with eliminating measures that either did not have good psychometric values or were redundant based on another measure capturing the same information in a more time-efficient or less expensive method. Specifically, this stage of the study provided an opportunity to assess the validity of the newly designed measures against the gold standard reference tools. Only those items that were considered functionally relevant and appropriate, with moderate to strong statistical relationships with the appropriate gold standard reference measures (BOT2, VO₂peak relative to body mass and 20m-MSRT) were included in the refined KidFit Screening Tool. The refined KidFit Screening Tool included two measures: The MSTP and the SAMS.

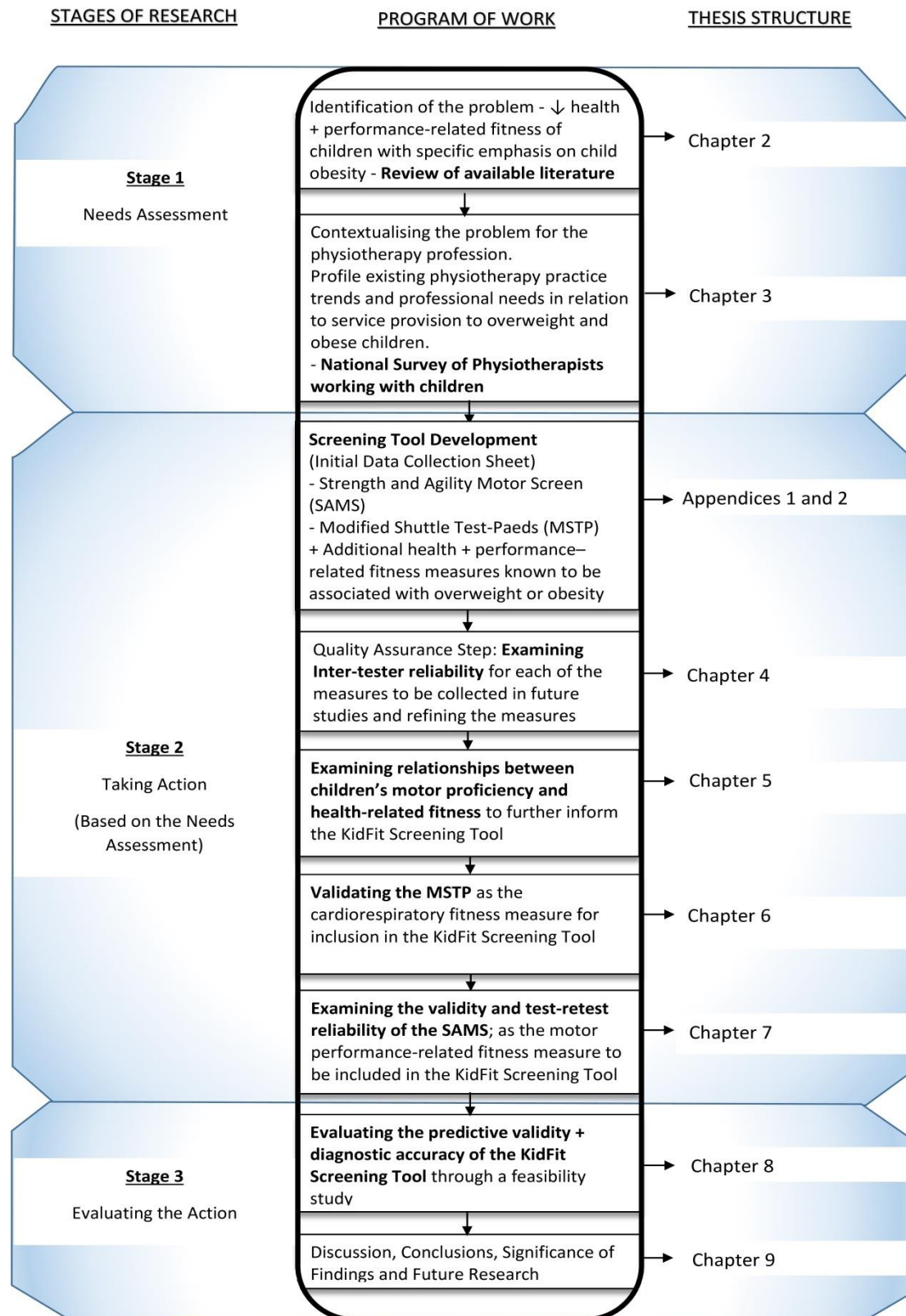
1.2.3 Stage 3 – Evaluating the Action (The KidFit Screening Tool)

- a. Evaluating the predictive validity and diagnostic accuracy of the refined KidFit Screening Tool* in a feasibility study.

This stage of the research program and screening tool development involved applying the KidFit Screening Tool to a cross sectional cohort of children aged 5 – 17 years. This study helped to determine if the KidFit Screening Tool could assist with accurately identifying children with and without overweight or obesity, poor motor proficiency and/or poor cardiorespiratory fitness who therefore warranted a referral to specialised services (e.g. Paediatric physiotherapists) for detailed assessment and intervention.

Across the three stages of tool development a series of reliability, validity, association and diagnostic accuracy studies, in addition to a national survey of Physiotherapists' were undertaken to meet the aims of this research program.

Figure 1.1. An overview of the research reported in this thesis and its relationship to the stages of development for the KidFit Screening Tool.



1.3 AIMS AND OBJECTIVES OF THIS DOCTORAL RESEARCH

The overarching objective of this research program was to:

1. Develop a simple, valid and reliable tool that possessed good diagnostic accuracy for screening the health and motor performance-related fitness of children that could be used to guide the referral process to physiotherapy for detailed assessment and intervention, when motor incompetency is thought to be a contributing factor to a child's poor health-related fitness.

A number of research aims were developed for this doctoral research, to achieve the overarching objective:

1. Establish the current trends in physiotherapy practice for the assessment and management of overweight and obese children.
2. Establish the professional needs of Physiotherapists to work with overweight and obese children and their families.
3. Establish the inter tester reliability of the newly designed measures proposed for inclusion in the KidFit Screening Tool.
4. Determine if associations existed between a number of health and motor performance-related fitness measures in Queensland children.
5. Establish the validity of the newly designed measures to be included in the screening tool – KidFit Screening Tool.
6. Determine the diagnostic accuracy (including sensitivity and specificity) of the KidFit Screening Tool for identifying children with overweight or obesity, reduced motor skills and/or reduced cardiorespiratory fitness that could be used to guide the referral process to paediatric physiotherapy services.

1.4 SIGNIFICANCE OF THIS DOCTORAL RESEARCH

The findings from this research have significance for professionals who are involved in the development of children's health and motor performance-related fitness, particularly those who work with large populations of children such as physical education (PE) teachers and coaches and those who would receive referrals for assessing and managing children with overweight or obesity, gross motor incompetency or reduced cardiorespiratory fitness. Information from this doctoral research will provide those who work with children, with an easy to apply screening tool (KidFit Screening Tool) that can be used to inform decisions regarding referral of children with overweight/obesity, poor motor skills, and/or reduced cardiorespiratory fitness, to paediatric physiotherapy services or other suitably qualified professionals for detailed assessment and intervention. As exercise capacity is known to decrease all-cause mortality (Lee & Skerrett, 2001) independent of adiposity (McAuley, Kokkinos, Oliveira et al, 2010), the KidFit Screening Tool is applicable to screening all children, not just those who are overweight or obese. This newly designed screening tool includes two measures which are important indicators of exercise capacity; the Modified Shuttle Test-Paeds (MSTP) which provides an indication of cardiorespiratory fitness and; the Speed and Agility Motor Screen (SAMS) which provides information about motor proficiency, both of which are important for children to be physically active.

1.5 THESIS PRESENTATION

This thesis is presented in a paper-based style. Initially a general and narrative literature review discusses the relevant background regarding overweight and obesity and reduced cardiorespiratory fitness in children and the personal, professional and economic impacts of this chronic condition in Australia and internationally. Thereafter the thesis is comprised of the following studies:

1. “Child obesity service provision: a cross sectional survey of physiotherapy practice trends and professional needs” (Chapter 3).
2. “Development of a tool for screening the health and performance-related fitness of children: inter-tester reliability of anthropometric and motor fitness measures” (Chapter 4).
3. “The relationship between children’s motor proficiency and health-related fitness” (Chapter 5).
4. “Modified Shuttle Test-Paeds: a valid cardiorespiratory fitness measure for children” (Chapter 6).
5. “Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children” (Chapter 7).
6. “Diagnostic accuracy of the KidFit Screening Tool for identifying children with and without health and motor performance-related fitness impairments: a feasibility study” (Chapter 8).

Thereafter, a summary and discussion of the overall thesis is provided, conclusions are drawn and areas for future research are presented.

CHAPTER 2.

REVIEW OF THE LITERATURE

2.1 Introduction

This chapter explores the prevalence and impact of childhood obesity and poor cardiorespiratory fitness in both Australian and global contexts and discusses implications for clinical assessment including screening of children with poor health and performance-related fitness (including overweight and obesity) to guide the referral process to physiotherapy intervention. The research questions emerging from this review will complete one component of the needs assessment and contribute to the methodology of each stage of the PhD research program.

2.2 Child Overweight and Obesity: Understanding the issue in Australian and global contexts.

The purpose of this section is to explore the currently accepted terminology used with regards to overweight and obesity, as well as to review the epidemiological evidence about overweight and obesity on a state, national and international scale. The aetiology, clinical health related progressions and disability, economic impact and approaches to prevention and intervention of obesity are investigated. Finally, the role of the Physiotherapist in working with overweight and obese children and their families is defined before outlining the need for new measures for inclusion in a tool to assist PE Teachers, coaches and Health professionals to make better decisions about referring children with poor health and performance-related fitness to Physiotherapy services.

2.3 Definitions

Obesity is defined as a condition where excess body fat (adipose tissue) has accumulated to the extent where health becomes negatively affected or is at risk of doing so (Crowle & Turner, 2010). The World Health Organisation (WHO, 2000) accepted the four widely used weight categories for adults using Body Mass Index (BMI) scores: underweight (BMI less than 18.5), normal weight (18.5 – 25), overweight (25 – 30) and obese (over 30).

The definition of overweight and obesity in childhood based on BMI is a more complex issue as evidenced by a recent review (Rolland-Cachera, 2011). In 2003, the Australian National Health and Medical Research Council recommended the use of the CDC 2000 growth standards (NHMRC, 2003) and most states and territories in Australia now implement this recommendation for children aged 2 – 18 years. More recently The Endocrine Society, endorsed the views of an expert panel in the child obesity field in the newly developed clinical guidelines for the prevention and treatment of paediatric obesity, recommending the use of BMI (calculated as weight in kilograms divided by height in meters squared), with CDC derived normative percentiles, as the preferred method for the diagnosis of overweight or obesity in children and adolescents (August, Caprio, Fennoy et al, 2008). Moreover, this expert panel placed high value on the identification of children and adolescents with high BMI (i.e. overweight and obesity) to enable targeting recommended clinical interventions to those individuals and furthermore they placed relatively low value on avoiding the potential psychological and socioeconomic consequences (e.g. labelling and medicalisation) of such practice (August et al, 2008). The CDC derived age and gender specific BMI percentiles, account for body composition changes during development and relate to the following cut-off points: overweight (85th percentile – 95th percentile) and obesity (>95th percentile). In 2000 the International Obesity Task Force (IOTF) endorsed international cut-off ranges for BMI (Cole, Bellizzi, Flegal, Dietz, 2000). However, due to a lack of a consistent approach to BMI classification and cut-offs for overweight and obesity for children, more recently Cole and Lobstein (2012) produced the extended international

(IOTF) BMI cut-offs for thinness, overweight and obesity and encouraged these to be used for epidemiological studies. These revised IOTF cut-offs for children correspond with a BMI at 18 years of 25 for overweight, 30 for obesity and 35 for morbid obesity with cut-offs available for exact ages from 2 – 18 years. As the CDC BMI percentiles were most commonly utilised throughout Australia at the time of this PhD research program commencing in 2009, and parents were to receive detailed reports of their child's results from participation in these studies, the CDC BMI percentiles and cut-offs have been used for classifying children with overweight or obesity in all studies that are a product of this PhD research program.

2.4 Prevalence and Trends

With regards to classification for overweight and obesity, the 2011-12 Australian Health Survey ((Australian Bureau of Statistics (ABS), 2011)) found that 70.3% of adult men and 56.2% of adult women were overweight or obese. This figure has risen steadily over the last 2 decades with 68% of men and 55% of women reported to be overweight or obese in the 2007-08 National Health Survey and 64% of men and 49% of women overweight or obese in the 1995 survey (ABS, 2009).

It is of considerable concern that it is not just the adult population who have grown in weight over the last few decades. The 2007 Australian National Children's Nutrition and Physical Activity Survey reported that 17% of Australian children were overweight and 6% were obese (23% total in the unhealthy weight range), (Department of Health and Ageing, 2008). This statistic was slightly lower in Queensland children with the Healthy Kids Queensland Survey in 2006, finding that 19.5% of boys and 22.7% of girls aged 5 – 17 years were overweight or obese (Abbott, Macdonald, Mackinnon et al, 2007). Evaluation of national data since 1985 demonstrated an approximate twofold increase in child overweight and obesity in both girls and boys across a two decade period (Margary et al, 2001). However, recent research suggests that in some developed countries obesity rates have been levelling off since 1999 (Rokholm, Baker

& Sorensen, 2010) including Australia where the child overweight and obesity rates have demonstrated no significant change since the 2007-08 National Health Survey, holding steady at approximately 25% (ABS, 2011). There is however, a strong consensus amongst obesity experts that the current levels are still unacceptably high.

2.5 Aetiology of overweight and obesity in children

A simple view to the cause of overweight and obesity is to suggest that it is merely a consequence of an energy imbalance, where energy intake exceeds energy expenditure resulting in a positive energy balance. However, the reality is that overweight and obesity are inherently complex conditions in regards to aetiology, with many factors interacting together. Causes include lifestyle choices resulting in a lack of physical activity and or excess consumption of energy, inherited genetic characteristics, environmental exposure and psychosocial factors.

In 2001, Davidson and Birch, developed a framework (see Figure 2.1) for the possible causes of, or factors associated with child overweight and obesity. The framework sets out three main areas:

- Child characteristics and behaviours (genetics, dietary intake, physical activity and sedentary behaviour)
- Parenting styles and family characteristics – which can impact on a child's behaviour
- Community, demographic and societal characteristics – which can influence parents, families and children's behaviours, including advertising, socioeconomic status (SES), education, ethnicity and the physical environment.

Diagram removed due to copyright.

Figure 2.1 Framework for factors associated with obesity and overweight

*= Child risk factors (in upper case lettering) refer to child behaviours associated with the development of overweight. Characteristics of the child (in italics) interact with child risk factors and contextual factors to influence the development of overweight and obesity (i.e. moderator variables). (Davison & Birch, 2001).

In this framework the factors in the outer layers can and do affect the factors in the inner layers and therefore all have the ability to impact on the child's behaviour and the child's family behaviour and consequently their weight and health status.

There is strong evidence for a significant genetic component to overweight and obesity with parental obesity being a strong risk factor for future, if not present, obesity (NHMRC, 2013). At least six very rare mutations of single-genes causing severe early-onset obesity have been identified (Crowle & Turner, 2010). Silventoinen, Rokholm, Kaprio & Sorensen (2010) found in an international review of twin and adoption

studies that genetics had a strong effect on BMI variation across all age ranges, with the effect proving stronger than the environmental influences.

In addition to the genetic influences, an international review of the literature revealed a consistent and positive relationship between birth weight and BMI in childhood and that child overweight and obesity are strong risk factors for adult overweight and obesity (Parsons, Power, Logan & Summerbell, 1999). Additionally a retrospective cohort study of 8494 children by Whitaker (2004) demonstrated that among low-income children, maternal obesity in early pregnancy more than doubles the risk of obesity at 2 to 4 years of age.

The Avon Longitudinal cohort study of 8234 children aged 7 years, found eight factors in early life were associated with an increased risk of obesity in childhood, supporting the notion that the environment in early life plays a role in determining risk of later obesity (Reilly, Armstrong, Dorosty et al, 2005). These early life risk factors included parental obesity (both parents), very early (by 43 months) BMI or adiposity rebound, more than eight hours spent watching television per week at age 3 years, catch-up growth, standard deviation score for weight at age 8 months and 18 months; excessive weight gain crossing upward centiles in first year; birth weight, per 100g; and short (< 10.5 hours) sleep duration at age 3 years (Reilly et al, 2005).

Parental obesity may increase the risk of their child having obesity through genetic mechanisms or by shared familial characteristics in the environment such as food consumption preferences (Francis, Lee & Birch, 2003).

Modern Australian society (with industrialisation, economic development, urbanisation and changes in technology) has and largely is, contributing to the obesity epidemic we are facing, with a host of epidemiological studies supporting this notion. Many of the studies investigating dietary and physical activity behaviour on Australian children have relied on self / parent reported data (not directly measured). This has

produced limitations regarding accuracy and capacity to make causal references. However, this data still provides us with strong patterns of behaviour which demonstrate significant correlations with obesity and obesity-related conditions that should not be ignored.

Over the past decade the term 'obesogenic' has been commonly used to describe environments and behaviours which are conducive to the development of obesity. Rapid urbanisation with densely packed developments (Lake & Townsend, 2006) and little open space for active play and physical activity are examples of an obesogenic environment.

Boehmer, Lovegreen, Haire-Joshu, and Brownson (2006) reported on a number of perceived factors which constituted an obesogenic environment in rural communities which were associated with actually being obese. These included living furthest from the nearest recreational facility, unpleasant community for physical activity and feeling unsafe from crime or traffic.

Since leading experts (Egger & Swinburn, 1997) in the field of obesity, argued for an ecological paradigm for understanding obesity, suggesting that 'obesogenic environments' in modern times were responsible for inducing 'obesogenic behaviour', a number of systematic reviews have been conducted on studies investigating environmental factors and obesity related behaviours, which have yielded little evidence for an association between environmental factors and weight-related behaviours (Brug, Van Lenthe & Kremers, 2006). In part, it is thought that this is due to the poor research design in many studies and due to the use of non-validated self-reported measures and so this view should not be taken as absolute truth.

It has been demonstrated by many researchers that society offers adults and children continual opportunity to consume appetizing energy-dense low nutrient foods with the ability to perform activities of daily living with only minimal physical activity and

exertion (Swinburn, Caterson, Seidell & James, 2004; Mayor, 2004; Schwartz & Puhl, 2003). For example, a recent spatial analysis in Chicago, USA found that fast food restaurants clustered around schools (Austin, Melly, Sanches et al, 2005). The reviews of 112 intervention studies reported by Brug et al (2006) indicated strong evidence for positive effects of physical and socio-cultural environmental changes, on eating and physical activity behaviours, rather than targeting societal level changes to the environment.

Based on the available literature, there appears to be a consensus that in order to tackle the current obesity epidemic, individuals must make behavioural changes that may be enhanced by multidisciplinary input. To enhance the opportunity to do so, there must be broader ecological approaches to the prevention of obesity supported by government policy.

With the ever increasing academic demands of children (leading to non-recreational screen time) and with increased requirements for time spent on non-physically active curriculum areas, we are seeing our population of children become more overweight and less fit (Department of Health, 2008). Abbott et al (2007) found that more than two in five boys overall and one in four Year-10 girls exceeded the current daily recommendations for time spent on screen-based electronic media and that this trend generally increased with age. The prevalence of overweight and obesity in Queensland children was shown to demonstrate similar trends of increasing with age, stretching towards the upper end (i.e. obese and very obese) although the prevalence of obesity was actually highest in Year 5 girls (Abbott et al, 2007).

Increased and enhanced opportunity for accessing recreational media may also be blamed for the excessive weight gain in children. A population based study by Hernandez, Gortmaker, Colditz et al, (1999) of children in Mexico City found that with each additional hour of television viewing per day, the risk of obesity was increased by 10%. This positive correlation between time spent viewing television and obesity risk

factors was supported by a more recent Australian study by Salmon, Campbell and Crawford (2006) who found that children who watched television for more than two (2) hours per day were significantly more likely than children who watched television for less than two (2) hours per day to consume more high energy drinks and savoury snacks and were less likely to have two (2) or more serves of fruit per day or participate in any organised physical activity. This may be largely blamed on the vast number of advertising campaigns for high energy, low nutrient-dense foods and the food industry meeting the needs of busy families by producing growing varieties of easy to consume individually packaged foods.

The growing number of fast-food outlets opening in new densely populated estates may increase the likelihood of the high protein, high fibre and low fat diet being replaced with higher fat and higher energy diet that has lower nutrient intake. Fast-food consumption has a strong positive association with weight gain and insulin resistance, suggesting that the consumption of fast food increases the risk of obesity and Type 2 diabetes (Pereira, Kartashov, Ebbeling et al, 2005).

Apart from spending increasing amounts of time with electronic media, which is correlated with poorer dietary intake and the reductions in time allocated to participation in organised sport and physical activity (Mohr, Wilson, Dunn, et al, 2007), children and adolescents are demonstrating lower absolute and incidental physical activity levels (Catford & Caterson, 2003). This could be attributable to an 'obesogenic' environment where parents' perceive unsafe environments for children to walk to school in addition to an increased requirement or access to electronic media. Irrespective of the cause, these are dangerous trends for the wellbeing of our children, leading to significant health related consequences associated with overweight and obesity.

2.6 Clinical health-related progressions and disability associated with overweight and obesity

There are extensive perceived personal costs to children with overweight or obesity, including social-emotional, psychological, physical and functional impairments. In addition to physical health problems, obese children are thought to frequently experience discrimination which may impact on their psychological well-being and contribute to their quality of life which has been shown to be compromised (Tsiros, Olds, Buckley et al, 2009). For example, severely obese children and adolescents have been shown to have lower health-related Quality of Life (QOL), including physical, emotional, social, and school functioning, than children and adolescents who are healthy and comparable QOL to children diagnosed with cancer (Schwimmer, Burwinkle & Varni, 2003). Other known psychosocial effects of childhood obesity include; adoption of high-risk behaviours, decline in self-esteem, loneliness, nervousness, anxiety, sadness, depression and negative self-image (Ebbeling, Pawlak & Ludwig, 2002).

However, in another large scale longitudinal study using a nationally representative sample of US adolescents; Swallen, Reither, Hass and Meier (2005) found that although obesity in adolescence was linked to poor physical quality of life in the general population, adolescents with above normal BMI in overweight range (but not necessarily obese) were conversely not found to have poorer emotional, school, or social functioning.

Overweight and obesity is however, known to increase a child's risk of poor physical health and obese children have a greater risk of developing asthma (Figueroa-Munoz, Chinn & Rona, 2001; Gennuso, Epstein, Paluch, & Cerny, 1998) and cardiovascular disease risk (Freedman, Dietz, Srinivasan & Berenson, 1999; Maffeis, Pietrobelli, Grezzani, et al, 2001; Kelishadi, Gheiratmand et al, 2007). Autopsy studies, such as the Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Study and the Bogalusa Heart Study, have demonstrated that the atherosclerotic process begins in

childhood (Wattigney, 1998; McGill, McMahan, Zieske et al, 2001; McGill, McMahan, Malcolm et al, 1997).

Overweight and obesity is also linked to the metabolic syndrome (Morrison, Aronson Friedman et al, 2008) and Type 2 diabetes; a clinical sequelae which is commonly referred to as 'diabesity' (Zimmit, 2003). Other health related consequences of childhood obesity include; chronic inflammation, which is linked to the metabolic syndrome, endothelial dysfunction (Gielen & Hambrecht, 2004), hypertension, pulmonary complications, increased tendency for blood clotting, kidney dysfunction, fatty liver disease (Sartorio, Del Col, Agosti et al, 2007), neurological complications and sleep apnoea (Ebbeling et al, 2002).

There is a positive association between level of obesity and musculoskeletal disorders, physical disability and osteoarthritis (Dixon, 2010). The most common orthopaedic morbidities associated with overweight and obesity in children include Blount's Disease due to the suppression of epiphyseal growth as a result of the increased pressure from weight to the growth plate (Thompson & Carter, 1990) and slipped capital femoral epiphysis (SCFE) which requires surgical intervention for management. A recent review of the literature by Tsiros, Coates, Howe et al, (2011) found that childhood obesity was associated with deficits in function, musculoskeletal pain, decrements in muscle strength, gait and balance. Although, each of the above mentioned conditions alone could cause tremendous burden to the individual, they also pose a major economic burden on society in the short and long term.

2.7 The socio-economic burden of overweight and obesity

Obesity or the so called "New World Syndrome" as described by Gracey (1995) has created an enormous socioeconomic and public health burden globally, and has led to disproportionate morbidity and mortality from increased rates of Type 2 diabetes, hypertension, dyslipidaemia and cardiovascular disease as well as other health-related

sequelae, in newly industrialised countries undergoing rapid modernization with growing affluence, even amongst ethnic minorities and socioeconomically disadvantaged people in developed countries. (WHO, 2000)

Taking into account \$8.3 billion of direct financial costs and \$49 billion worth of lost wellbeing with regards to productive citizenship, Access Economics (2008) estimated that the total annual cost of obesity (including diseases attributable to obesity) in Australia was \$58.2 billion per year. Whilst there is much discussion about the cost of obesity being very high, there is very little evidence about the direct and indirect costs of obesity in children. Although a US study (Johnson, McInnes & Shinogle, 2006) suggests that medical expenses of overweight and obese children do not differ greatly from other children, costing the US approximately \$127 million annually this is likely to be an underestimate. With the Queensland and Australian Governments listing 'obesity' and associated chronic disease as a high priority area for prevention and intervention and the incidence of obesity-related chronic ill health occurring earlier in life each decade, health spending to deal with such a significant epidemic is likely to increase significantly.

2.8 State and National priorities for the reduction of overweight and obesity in children and adults and the prevention of associated chronic disease

In light of the financial burden that obesity causes, the Australian Government assembled a Preventative Health Taskforce to provide recommendations for guiding our Nation to better, and in fact, good health by 2020. In order to halt and reverse the rise in overweight and obesity in Australia, the following initiatives were recommended by the Preventative Health Taskforce:

- Reshape the food supply towards lower risk products and encourage physical activity

- Protect children and others from inappropriate marketing of unhealthy foods and beverages
- Improve public education and information
- Reshape urban environments towards healthy options
- Strengthen, up skill and support primary healthcare workers and the public health workforce to support people in making healthier choices
- Develop maternal and child health initiatives
- Close the gap for disadvantaged communities
- Build the evidence base, monitor and evaluate effectiveness of actions, and
- Develop a national food strategy for Australia

Further to this, in 2008 the Queensland Government released the *Toward Q2: Tomorrow's Queensland* document (2008) indicating a 2020 target of cutting obesity by one third across the general population of adults and children. This target leaves us with just over half a decade to turn around a problem which has progressively grown over a three decade period and will require a united major commitment across all public and private sectors of health, education, disability, community services and political bodies.

2.9 Intervention and management approaches to overweight and obese children and their families

In Australia and other developed nations there have been a variety of approaches taken for prevention and management of overweight and obese children and their families. An Australian Institute of Health and Welfare report, *A picture of Australian children* (AIHW, 2009), identified physical activity as an important element in children's health and well-being. Physical activity has been shown to reduce cardiovascular risk factors, protect against some types of cancer and strengthen the musculoskeletal systems (AIHW, 2009; NHMRC, 2003). Physical activity also improves children's psychosocial well-being and learning opportunities by reducing symptoms of

depression and anxiety and improving self-esteem (Biddle & Asare, 2011). Such relationships between physical activity and positive health and wellbeing have led to the development of many intervention studies and programs. This section of the literature review, investigates the approaches and the evidence supporting the various methods for preventing and managing childhood overweight and obesity.

There have been four Cochrane reviews that are directly relevant to the topic of child obesity or physical activity and fitness in children. The first titled 'Interventions for preventing obesity in children' (Summerbell, Waters, Edmunds et al, 2009) investigated 22 studies (10 long term: > 12 months and 12 short term: 12 weeks to 12 months) that were either school, community or family based. Six of the 10 long term studies included dietary education and physical activity and out of those, 5 had no impact on overweight status. Two studies focused on physical activity alone, one of these taking a multi-media approach, showed some positive results and out of the 2 studies which targeted nutritional education alone, neither was effective in making changes to weight status. For the 12 short-term studies, 4 studies focused on increasing physical activity and 2 showed minor improvements in weight status. However, the other 8 studies which combined advice on increasing physical activity and improving dietary intake showed no significant improvements at all. This Cochrane review was updated two years later (Waters, de Silva-Sanigorski, Burford et al, 2011) and included an additional 36 studies with the majority of those targeting obesity prevention in 6-12 year old children. The authors of this updated Cochrane review concluded that there was strong evidence that obesity prevention programs had beneficial effects in reducing BMI and after synthesising the results, suggested that policies and strategies around the following points could be of benefit: school curriculum that addresses healthy eating, physical activity and body image; increased physical activity and development of fundamental movement skills during the school week; improved nutritional options at school; environmental and cultural changes to eating habits; health promotion activities in schools; parent support for home activities

to be more active; less sedentary behaviour and eating more nutritious food (Waters et al, 2011).

The second Cochrane review; 'Interventions for treating obesity in children' (Luttikhuis, Baur, Jansen et al, 2009) investigated 64 studies providing interventions for treating obesity in children, for which 54 studies investigated multidisciplinary lifestyle approaches to treatment (focussing on diet, physical activity or behaviour change). This review demonstrated that lifestyle programs can have a positive effect in reducing the level of overweight in child and adolescent obesity at 6 and 12 months post program implementation. Ten studies in this review examined the effect of drug treatment to reduce overweight and obesity in children, with the authors concluding that when either drug orlistat or sibutramine were given in addition to a lifestyle program, there was a reduction in overweight status, however a range of adverse effects were also noted from these studies. A weakness of many of the studies included in the review includes the lack of long-term outcomes or longitudinal follow-up, which is a common problem in paediatric-based studies especially those involving groups of individuals from lower socio-economic backgrounds due to the transient nature of these populations.

Dobbins, DeCorby, Robeson et al, (2009), completed a Cochrane review investigating school-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18 years. This review found that school based physical activity interventions were generally effective in developing healthy lifestyle behaviours among children and adolescents which is proposed to translate into reduced risk from many chronic disease and cancers in adulthood. Dobbins et al (2009) demonstrated that school-based physical activity interventions were effective at increasing physical activity duration, reducing blood cholesterol, increasing VO₂max (as an indicator of physical fitness) and reducing time spent watching television. Conversely, the school-based interventions were not found to be effective in increasing the percentage of children and adolescents who were physically active

during leisure time, reducing blood pressure, BMI or pulse rate (Dobbins et al, 2009). It should be noted however, that the interventions in this review focused on providing teachers and students with information and resources about the benefits of physical activity and health nutrition and the risks of inactivity and unhealthy food choices. This Cochrane review was subsequently updated four years later (Dobbins, Husson, DeCorby & LaRocca, 2013) and with the addition of new inclusion criteria eliminated 12 of the previous 26 studies and included a total of 44 studies. This latest review (Dobbins, Husson, DeCorby & LaRocca, 2013) demonstrated few changes in results with the exception of blood cholesterol which was no longer positively impacted by school-based physical activity interventions with moderate to vigorous physical activity rates now positively impacted.

Very few school-based studies focused on direct intervention with 'at risk' overweight or obese children in order to improve health status. These kinds of programs are rare in school environments as there is perceived potential for stigmatisation of overweight or obese children, which is commonly believed to negatively impact on self-esteem, self-worth and mental health. However, Ebbeling et al (2002) point out that obesity in childhood (even without a targeted approach to intervention at school) results in decreased self-esteem, loneliness, nervousness, anxiety, sadness, depression and negative self-image. In an investigation of the literature surrounding the impact of obesity prevention programs on eating pathology, Carter and Bulik (2008) showed that participants receiving an active intervention either did not differ significantly from their 'non-intervention' based controls or they experienced significant benefits on the psychological measures assessed. These findings led the authors to conclude, that the existing evidence does not support the view that child obesity prevention programs are associated with unintended psychological harm (Carter & Bulik, 2008). The most recent Cochrane review on obesity prevention programs for children (Waters et al, 2011) supported this notion, reporting that no adverse outcomes such as unhealthy dieting, increased prevalence of underweight or body image sensitivities were noted as a result of obesity prevention programs.

In support of increasing physical activity for children, the Queensland government have endorsed the 'Smart Moves' campaign in state schools, which acts to increase the curriculum time students are engaged in moderate intensity physical activity at school and to improve the quality of that activity. Specifically all primary schools must allocate 30 minutes per day of at least moderate intensity physical activity as part of the school curriculum and secondary schools are required to provide only two hours of at least moderate intensity physical activity per school week. However, this does not ensure that school age children reach the current nationally advised physical activity guidelines (Commonwealth of Australia, Department of Health and Ageing, 2014) of performing at least 60 minutes (and up to several hours) of moderate to vigorous physical activity every day. Further work is thus required in Australia and Queensland to improve school-based prevention and intervention of overweight and obesity in children and adolescents.

Excessive body fat at a young age is associated with lower cognitive, school and later life achievement, which prompted the most recent Cochrane review relevant to this thesis which investigates lifestyle interventions for improving school achievement in overweight or obese children and adolescents (Martin, Saunders, Shenkin & Sporoule, 2014). This review yielded six studies for analysis and found that physical activity specific programs had small but positive effects on mathematics achievement, executive function and working memory and; multicomponent lifestyle programs (incorporating physical activity and healthy diet) had small improvements in overall school achievement (Martin et al, 2014). In an attempt to curb the obesity epidemic and its associated health and education sequelae, the results of these reviews suggests that it may be worth considering further targeted obesity prevention and intervention programs in schools. If this were to occur, a screening tool which could be used by PE Teachers, coaches and health professionals, to identify children with poor health and motor performance-related fitness, could be beneficial. Specifically, the application of such a screening tool could assist with making decisions about referring a child to

specialised services for detailed investigation of their poor health or performance-related fitness. Subsequently, targeted and suitable intervention could be planned and implemented. It is proposed that physiotherapists could make a significant contribution to the management of children with obesity when poor motor skills or poor cardiorespiratory fitness underpins their reduced physical activity.

2.10 The current role of Physiotherapist's in working with overweight and obese children

In 2009, the Australian Physiotherapy Association (APA) released a position statement titled 'Chronic Disease and Physiotherapy'. This document refers to the role of physiotherapists in dealing with the conditions outlined in the National Chronic Disease Strategy (NCDS), which identifies the national health priority areas as asthma, cancer, diabetes, heart, stroke and vascular disease, osteoarthritis, rheumatoid arthritis and osteoporosis, the majority of which are firmly associated with overweight and obesity.

The APA document their role in relation to chronic disease, as assisting people who are at risk of developing or already have a chronic disease, to safely maximise their level of physical activity and manage their own care (APA, 2009) either through health promotion activities or via direct intervention such as exercise prescription for asthma (Cambach, Wagenaar, Koelman et al, 1999), individualised prescription of exercise therapy to improve glucose and insulin control in people with or at risk of Type 2 diabetes (Yassine, Marchetti, Krishnan et al, 2009) and cardiac (Jolliffe, Taylor & Ebrihaim, 2000) and stroke rehabilitation programs (Forster & Young, 2002). Specifically relating to childhood overweight and obesity, the Australian physiotherapy profession have not yet clearly enunciated their role. However, there are three critical points which indicate the appropriateness of paediatric physiotherapists being involved in the assessment and therapeutic process for overweight and obese children.

Firstly, physiotherapists work as first contact practitioners within primary care settings such as ambulatory services, private practices, community health settings, hospitals and in some instances schools. Working in these settings places them in an ideal position to provide prevention and or intervention to children and adolescents suffering from or at risk of overweight or obesity and associated poor health and well-being.

Secondly, the core role of paediatric physiotherapists is to work with children and adolescents to promote optimal physical function and enhance the development of the musculoskeletal, neurological and cardio-respiratory systems. Physiotherapists are therefore primarily concerned with movement, coordination, balance, posture, gross motor function and physical fitness. Paediatric physiotherapists work closely with families, carers, teachers, doctors and other health professionals in a holistic approach to optimise health and prevent or minimise the effects of physical impairment, which ultimately provides the child with opportunities for socialization with peers and maximised learning prospects in the quest of becoming a creative and productive citizen. Children with weight problems have associated fitness impairments (Haga, 2008a) and are often poorly coordinated with motor skill deficiencies, thus making it harder for them to be active. This creates a vicious cycle of further sedentary behaviour, decreased physical activity, and worsening states of health and performance-related fitness. Improving fundamental movement skills (a core role of physiotherapists) has been shown to increase the enjoyment of physical activity (Okley & Booth, 2000). Thus one could reasonably assume that an increase in the enjoyment of physical activity would result in an actual increase in the amount of physical activity being undertaken.

Cantell et al, (2008) found that children and adolescents with lower motor competence had significantly higher BMIs compared to those with high motor competence and that motor skills and static balance were significant predictors of BMI, therefore indicating that individuals with low motor competence have compromised health-related fitness.

Additionally, Oakley et al, (2004) found that BMI and waist circumference (WC) were significant predictors for ability to perform Fundamental Motor Skills (run, vertical jump, throw, catch, kick, and strike).

Thirdly, physiotherapists (especially those with Exercise Science undergraduate degrees) are suitably trained to assess motor ability and fitness and prescribe targeted and individualised exercise therapy to:

1. Improve the health of overweight or obese children.

Woo, Chook, Yu et al, (2004) evaluated the reversibility of obesity-related arterial dysfunction and carotid intima-media thickening and found that diet combined with customised exercise prescription by physiotherapists, was better than diet alone for reversing obesity related vascular dysfunction in otherwise healthy young children. Consistent with this, Meyer, Kundt, Lenschow et al, (2006) found regular physiotherapy-supervised exercise over 6 months restores endothelial function and improves carotid intima-media thickness (IMT) associated with an improved cardiovascular risk profile in obese children.

Physiotherapists are also endorsed (APA, 2010) to help children manage their asthma (a condition associated with obesity), and are able to offer assistance to the child and family regarding the use of medication delivery devices, management of inhalers, education about asthma, specifically exercise-induced asthma, a condition that may result in avoidance of exercise and participation in sport.

2. Improve the gross motor and fundamental motor skill proficiency of children.

A study investigating the effect of physiotherapy intervention on school aged children with Developmental Coordination Disorder (DCD), a condition which clinically appears to yield more overweight and obese children than in the non-diagnosed group, demonstrated improved sensory motor function as assessed on the Neuro-Sensory-Motor-Developmental Assessment – NSMDA, after a 12-week physiotherapy directed

intervention program (Chia & Choa, 2002). Similar findings were reported by Schoemaker, Hijlkema and Kalverboer (1994) in a study evaluating physiotherapy intervention for clumsy children. Additionally, Ketelaar et al, (2001) demonstrated positive gross motor outcomes from a functional physiotherapy program for children with mild to moderate spastic cerebral palsy.

Ketelhut, Mohasseb, Scheffler & Ketelhut, (2004), assessed the efficacy of a regular exercise program (3x per week) on blood pressure (BP), heart rate (HR), BMI and motor skills and found that with a regular exercise program inclusive of fundamental gross motor skills, children showed improved HR, BP and all motor skills, particularly balance, which is correlated with overweight and obesity (Deforche, Hills, Worringham et al, 2009; D'Hondt, Deforche, De Bourdeaudhuij & Lenoir, 2009) and coordination.

A systematic review of the effects of early intervention on motor development, by Blauw-Hospers and Hadders-Algra (2005) found that physiotherapy intervention inclusive of specific motor training, such as training of locomotor movements on a treadmill and general motor developmental programmes, enhanced a child's exploration of active motor behaviour, exerting a positive effect on gross motor development.

Although there is evidence to support the role of physiotherapists improving the gross and fundamental motor development of children with DCD, Down syndrome (Ulrich, Lloyd, Tiernan et al, 2008) and cerebral palsy, there are very few studies looking at the effectiveness of a physiotherapy-delivered gross motor skill-based intervention for overweight and obese children. This may be due to the fact that there is limited physiotherapy resources (staff) allocated to this population of children in Australia and throughout the world. In addition, there are few suitably developed screening and assessment tools and or outcome measures to investigate motor proficiency that have been developed validated for use with overweight and obese children. This highlights a definitive need for further research in this area. Thus it is considered that the

development of a screening tool (as outlined for development in this PhD research program) may help to identify children who are overweight or obese with motor incompetency or poor cardiorespiratory fitness, to efficiently reach paediatric physiotherapy services, for detailed assessment and targeted intervention.

2.11 The need for new measures to be incorporated into the screening tool to guide the referral process for physiotherapy intervention

An understanding of physical fitness as an entity, provides the framework for the development of a screening tool that accurately identifies the health and motor performance status of children.

Physical fitness is recognised as an entity that may be subdivided into two (2) categories (Haga, 2008b):

1. **Performance-related fitness:** Balance, coordination, speed, agility and power, which all reflect the performance aspect of physical fitness (Howley, 2001)
2. **Health-related fitness:** Cardiorespiratory endurance, muscular strength and endurance, body composition and flexibility (Howley, 2001) which are usually associated with disease prevention and health promotion (Powell, Casperson, Koplan & Ford, 1998).

Haga (2008a) examined physical fitness in 9 and 10-year-old children and found that children with impaired motor skills displayed reduced physical fitness on all nine subtasks and the total score on the Test of Physical Fitness. Subsequently Haga (2008a) hypothesised that the relatively poor physical fitness performance of the children with movement difficulties in the study, was due to lower levels of physical activity, indicating a spiralling 'chicken and egg' effect. Studies such as this, demonstrate the need for physiotherapy input to improve gross motor proficiency in order to increase

physical activity which in turn can improve health-related fitness. Thus a screening tool that can identify impaired motor proficiency for those with poor health-related fitness is required to assist with facilitating the referral process to physiotherapy. Such a tool could help bridge the gap between services already providing input to overweight and obese children and access to physiotherapy for assessment of motor skill deficiency for more targeted intervention.

Research in the physiotherapy / child obesity and fitness area is only just emerging in the literature. Studies such as those by Cantell et al (2008), Oakley et al (2004), and Haga (2008a), highlight the need for the development of a simple, time efficient, reliable, valid and accurate screening test of health and motor performance-related fitness which are known or predicted to be associated with obesity and the progression towards chronic disease and illness. Such a screening tool could be used by PE teachers, coaches and other health professionals to assist with referring appropriate children to physiotherapy services for more detailed assessment and targeted intervention.

Although a number of measures already exist for the assessment of health and motor performance-related fitness (see section 2.12), many are either too time consuming, too expensive or require highly specialised personnel to interpret the findings, preventing the inclusion of such tests for use in the proposed screening tool. A screening tool needs to be quick (approximately 5 minutes) and simple for implementation by many disciplines to be accepted and established as a functional tool in clinical practice. Consequently, components of the newly designed KidFit Screening Tool which had not previously been published have been validated against the gold standard test of motor proficiency (Bruininks Oseretsky Test of Motor Proficiency (2nd Edition) - BOT2) and other established fitness measures (e.g. VO₂peak relative to body mass). Such validated measures are discussed below.

2.12 Selecting the measures for inclusion in the development of the screening tool

Based on Howley's (2001) definitions of 'health-related' and 'performance-related' fitness, and the reported relationship that these have to overweight and obesity and the development of chronic disease, a number of measures were selected for detailed investigation into possible inclusions as part of this screening tool (The KidFit Screening Tool). Appendices 1 and 2 - Parent Database and Data Collection Sheet (the suite of tests used in data collection periods of the research program) highlight the range of measures from which the KidFit Screening Tool was developed.

The sections below consider the 'Health' and 'Performance' related fitness measures that were selected for investigation and development as part of the KidFit Screening Tool in this research program. Some of the measures have established validity and reliability and can be used as a gold standard reference against which new measures can be validated. Such measures are briefly outlined in the below sections. The newly developed measures for inclusion in the screening tool required validity and reliability to be established and are therefore discussed in more detail in the following sections.

2.13 Health-related fitness measures

Health-related fitness measures include; body composition (BMI and waist circumference), muscular strength and endurance, cardiovascular endurance (aerobic fitness), and flexibility. (Howley, 2001; U.S. Department of Health and Human Services, 1996). Blood pressure was also included in this research program as a measure of health-related fitness, based on the strong association between obesity and childhood hypertension (Din-Dzietham, Liu, Bielo & Shamsa, 2007) and poor cardiovascular fitness and hypertension in children (Chen, Fox, Haase & Wang, 2006).

2.13.1 Body Mass Index (BMI) with children

Many techniques are available to measure body fat, however many are too expensive or impractical for use in clinical settings. BMI, (which is a measure of weight in kilograms divided by the square of height in metres) has now been accepted as the standard clinical measure of adiposity for use internationally with adults (August et al, 2008). Although there has been much discussion in the past about the use of BMI for children, due to the variation in distribution with an individual's gender, age and also ethnicity, BMI percentiles were endorsed by the WHO (2000) and accepted as the standard measure of 'fatness' in children globally. The CDC derived age and gender specific BMI percentiles account for body composition changes during development and indicate the following cut-off points: overweight (85th percentile – 94th percentile) and obese (95th percentile and above) which are similar to the internationally accepted definitions as described by Cole et al (2000). Freedman and Sherry (2009) investigated the relationship of BMI to body fatness and health risks, in order to establish the validity of BMI as a true indicator of body fatness and risk among children and found that in relatively 'fat' children BMI was a good indicator of excess adiposity and that BMI for age has moderately high sensitivity and specificity and a positive predictive value for adverse risk factors associated with obesity. Additionally the traditional charting methods are considered reliable methods for deriving BMI percentiles (Poustie, Smyth & Cole, 2005).

More recently BMI Z scores based on CDC BMI percentiles or the IOTF values have become popular for categorising overweight or obese children. Caution should be taken in using BMI Z score categories as even though BMI Z-score is optimal for assessing adiposity on a single occasion, it is not necessarily the best scale for measuring change in adiposity, as the within-child variability over time depends on the child's initial level of adiposity (Cole, Faith, Pietrobelli & Heo, 2005). For example, an obese child during an intervention program, may show changes in BMI or BMI%, but will not change BMI Z score which could be detrimental to the motivation of the child and family and may in fact not demonstrate a change when change has occurred. Thus

the more sensitive measures to use for tracking change in adiposity are BMI and more specifically BMI % for children (Cole et al, 2005; Cole, Felgal & Nicholls, 2007) and consequently these measures were included in the suite of measures for investigation in this study.

2.13.2 Waist circumference and hip circumference measures

Central adiposity, as measured by waist circumference (WC), can be calculated from measurements taken using a standard measuring tape at the umbilicus or iliac crest (occasionally documented midway between the 12th rib and the iliac crest) and is a time efficient clinical measure for central obesity and a valid indicator of cardiovascular risk factors in children. Esmailzadeh, Mirmiran and Azizi (2006) took anthropometric and biochemical measurements from a cross-sectional group of 1413 male and 1623 female children and adolescents aged 10 – 19 years. In their study they defined hypertriglyceridemic waist (HW) phenotypes as those with triacylglycerol concentrations of $\geq 110\text{mg/dL}$ with a concurrent waist circumference $\geq 90^{\text{th}}$ percentile for age and sex, with results indicating that those with HW phenotypes had significantly higher prevalence's of all risk factors for metabolic disease (high LDL and low HDL cholesterol, hypercholesterolemia, and hypertension) except elevated fasting glucose.

Although waist circumference (WC) and WC-derived indices such as waist-to-hip ratio and waist-to-height ratio (WHTR) are being used currently as measures of central obesity, there is growing evidence to suggest that WC alone correlates more strongly with cardiovascular (CV) risk than WHTR, in children. Hirschler, Aranda, Calcagno et al, (2005), took anthropometric measurements (BMI, WC, BP) of 84 obese and non-obese children aged 6 – 13 years and oral glucose tolerance tests, lipid profiles and insulin and pro-insulin assays were performed on each child with results indicating that WC was an independent predictor of insulin resistance in children and adolescents, supporting its use in clinical practice as a simple tool to identify children at risk of metabolic diseases. Additionally, Sung, Yu, Choi et al, (2007), measured weight, height,

waist and hip circumference in 2593 (52% boys, 47% girls) school children aged 6–12 years with BP, fasting triglyceride, LDL and HDL cholesterol, glucose and insulin levels also measured in 958 of these children, finding that WC correlated slightly more than BMI with CV risk factors (excluding LDL cholesterol and glucose) concluding that WC is predictive of the population of children at risk of CV disease.

Standard WC cut-off values for high cardio-vascular risk have been proposed for adults (Lean, Han & Morrison, 1995; World Health Organization, 1998) and are widely used, but measurement of WC is not yet common practice in growing children due to the lack of internationally accepted reference ranges. Age-related percentiles have been reported for children from a number of different countries: Italy (Zannolli & Morgese, 1996); Spain (Moreno, Fleta, Mur et al, 1999); Cyprus (Savva, Kourides, Tornaritis et al, 2001); United Kingdom (McCarthy, Jarrett & Crawley, 2001); Canada (Katzmarzyk, 2004); USA (Fernandez, Redden, Pietrobelli & Allison, 2004); Holland (Fredriks, van Buuren, Fekkes et al, 2005); Iran (Kelishadi, Gouya, Ardalan et al, CASPIAN Study Group, 2007), and China (Sung, Yu, Choi, et al, 2007) but, the only published directly measured WC data for Australian children (with reference data) is a study by Eisenmann, (2005) which presents percentiles for children aged 7 – 15 years only and is based on data from the 1985 Australian Health and Fitness Survey with no subsequent studies since being documented. It is however, acknowledged that the 'Healthy Kids Queensland Survey' (Abbott et al, 2007) and other current studies in progress may yield more Australian data for publishing in the near future.

Currently, Australia does not have WC percentile charts for use in the clinical setting to compare our children to those in other countries, to use as a baseline for therapeutic change in the growing child, or to use as a screening tool for referring children to appropriate services. The review of the literature did not yield studies that demonstrate differences in waist circumference measures for children living in varying socio-economic, ethnic and geographical areas. For this research program, WC measures were planned for data collection due to strong correlations between WC and

CV risk factors and metabolic syndrome in adolescents (Cook, Weitzman, Auinger et al, 2003; Katzmarzyk, Srinivasan, Wei et al, 2004). In the shortfall of Australian reference data, US WC percentiles will be used.

2.13.3 Muscular strength and endurance

Deforche, Lefevre, De Bourdeaudhuij et al, (2003) in a study investigating physical fitness and physical activity in obese and non-obese children, found that absolute muscular strength was significantly greater in obese children and adolescents. However, once corrected for body mass, obese children have been shown to have reduced muscle strength (Tsiros, Coates, Howe et al, 2012) which results in decreased functional strength for use in every day weight-bearing activities (Tsiros, Buckley, Howe et al, 2012). Additionally, on tests of muscular endurance, obese children perform worse than non-obese children (Chen et al, 2006), suggesting that as muscular endurance tasks (e.g. sit ups and push ups and child play) require rapidly repeated gross motor movements of large percentages of body mass, it results in a more difficult undertaking for the obese child. As it is the speed and agility component of muscular endurance activities that obese children find more difficult (rather than pure muscular strength), it was not considered necessary to have a separate strength measure included in the proposed screening tool. With the BOT2 including a specific strength measure it was possible to monitor this measure in the preliminary phases of this study program. It was planned that if at the completion of Chapter 5 of this research program the results from the BOT2 (gold standard comparison tool) strength subtest revealed an association with overweight or obesity risk factors, then either a functional strength measure or directly measured strength test may have been included in the screening tool.

A new measure (the Speed and Agility Motor Screen - SAMS) was proposed for investigation as part of this research program. The SAMS was thought to incorporate the components of coordination, functional strength, balance, speed and agility in line with the challenges that these elements pose for overweight and obese children. As

the SAMS is considered a 'motor performance-related fitness measure' it is discussed further in section 2.14.3.

2.13.4 Cardiorespiratory fitness

Absolute VO_2 max (maximal oxygen uptake) is widely accepted as the most valid marker of cardiorespiratory fitness (CRF) (Shultz, Deforche, Byrne & Hills, 2011). However absolute VO_2 max is higher in obese children than non-obese children (Berndtsson, Mattsson, Marcus & Larsson, 2007). This is reported to be due to the increased fat mass which is associated with increased pulmonary effort (Rowland, 1991) as well as the increased fat-free mass which can be described as metabolically active tissue driving VO_2 max levels (Maffei, Schena, Zaffanello et al, 1994).

Goran, Fields, Hunter et al, (2000) used combined data from two studies (129 children across a wide spectrum of body composition and 31 overweight women) to investigate the influence of body weight and body composition on aspects of aerobic fitness. They measured VO_2 max, sub-maximal aerobic capacity with respiratory exchange ratio (RER), heart-rate, oxygen uptake relative to VO_2 max at a given workload (% VO_2 max), and body composition using dual energy X-ray absorptiometry (DXA) in the children with a four compartment model in the overweight women. Goran et al (2000) found that absolute VO_2 max was significantly higher but VO_2 max relative to body weight was significantly lower in obese children, whereas there was no significant difference between the obese and lean groups of children when expressed relative to fat free mass (FFM). Sub-maximal aerobic capacity was found to be significantly lower in the obese children as evidenced by higher HR and % VO_2 max and time to exhaustion was also significantly lower in the obese children. So although obese children demonstrate higher absolute VO_2 max and therefore apparent cardiopulmonary exercise capacity, the reality is that functional fitness is decreased in obese children because of their body weight and inert load created by excess body fat in weight bearing activities, which is the most functional daily activity required by children.

Therefore, VO₂max relative to body mass can be described as a valid measure of cardiorespiratory fitness in children. However, it is important to note that VO₂max testing is very rarely used in general clinical settings as it requires expensive equipment and takes a significant amount of time to complete and analyse the data. The test however, offers a gold standard reference for cardiorespiratory fitness for this research program, and enabled the validation of a more simple and appropriate measure of cardiorespiratory fitness; the Modified Shuttle Test - Paeds (MSTP) for inclusion in the KidFit Screening Tool.

Other tests of cardiorespiratory fitness which are more commonly used in a clinical or community environment includes the 20m Multi Stage Run Test (20m MSRT) (Leger & Lambert, 1982; Leger, Mercier, Gadoury & Lambert, 1988), or the alternatively named Progressive Aerobic Cardiovascular Endurance Run - PACER. Varness, Carrel, Eickhof and Allen (2009) demonstrated that a school-based test of cardiovascular fitness (PACER) was a valid test for predicting insulin resistance showing a similar relationship to IR when compared to complex laboratory testing which supports the idea of using a school based fitness screening test for identifying children at with poor health-related fitness such as those at risk of insulin resistance, an associated condition of obesity. The multi-stage aerobic fitness tests (e.g. 20m MSRT / PACER) are designed for groups of individuals to complete together and can take over 20 minutes to complete depending on fitness. In order to reduce any likelihood of stigmatisation by other children towards less fit children, a test which is shorter in duration, does not have a drop out nature and is therefore more suited to screening fitness in children in schools or professional environments is warranted.

The Modified Shuttle Test – Paeds (MSTP) has been newly designed to meet this need. It involves the child running a 10 metre shuttle, picking up a bean bag, turning around and running back to the start point to return the bean bag to a tray. This is repeated as many times as possible in 3 minutes. One (1) point is scored for every bean bag returned to the box and a further half (1/2) point is added if the test finishes after the

child has picked up a bean bag but has not returned it to the box. It is acknowledged that the MSTP involves some additional skills of grasping to pick up the bean bag, however this was intended to better engage young children in the activity as it is task oriented. The reliability and validity of the MSTP as a cardiorespiratory fitness measure for children requires validation against the gold-standard reference VO_2max relative to body weight, as well as the commonly used field test; the 20m Multi-stage run test.

2.13.5 Flexibility

Although obese children have demonstrated similar results to non-obese children in flexibility, using the Sit and Reach Test (Deforche et al, 2003; Chen et al, 2006), no reported studies have incorporated upper limb flexibility measures with overweight or obese children. For this reason a new Upper Limb Flexibility Test (ULFT) has been designed to allow easy and quick measurement using an inclinometer or angle finder on the triceps muscle of the child. During this test the child is standing upright as they extend their arms behind their body, whilst keeping their elbows straight and holding a standard sized bar between their hands. Both the Sit and Reach and the ULFT will be included in the suite of measures used for this research program and the reliability and validity of the ULFT will be investigated. Subsequently, the association of this measure with overweight and obesity in children will be determined. The Sit and Reach test has been chosen for inclusion based on the prominence of this measure in many musculoskeletal fitness tests commonly used throughout the world. Patterson, Wiksten, Ray et al (1996) found the sit and reach test had moderate validity to assess hamstring flexibility compared to goniometric measurement of hamstring length in school aged children. Based on the complexity of accurate goniometric measurement, and its moderate validity, the Sit and Reach test was chosen as a simple measure for indicating lower limb flexibility to compare to the new measure of ULFT.

2.13.6 Blood Pressure

A recent U.S. study (Din-Dzietham et al, 2007) investigating blood pressure trends in children and adolescents, found that hypertension and pre-hypertension were on the rise and indicated that obesity and more so abdominal obesity rises are the probable underlying cause. Considering the strong association between obesity and childhood hypertension (Din-Dzietham et al, 2007) and the results of a recent study of Taiwanese children with low levels of cardiovascular fitness being 30% more likely to develop hypertension (Chen et al, 2006), it is evident that BP before and after fitness testing should be included in a measure of health-related fitness. Associations between BP and motor performance-related fitness in overweight and obese as well as non-overweight or obese children and adolescents was thus investigated in this research program.

BP interpretation involved using the revised percentile charts provided by the US National Heart, Lung, and Blood Institute's Task Force Report on High Blood Pressure in Children and Adolescents (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996), where those with a systolic or diastolic blood pressure greater than the 90th percentile (adjusted for height, age and sex) were categorized as having high blood pressure.

In addition to these health-related measures, a number of motor performance-related measures were reviewed to ensure an appropriate selection of motor tasks were included in the screening tool.

2.14 Motor Performance-related Fitness Measures

Typical motor performance-related fitness measures include balance, coordination, speed, agility and power, and reaction time (Howley, 2001; U.S. Department of Health and Human Services, 1996). Motor competence has been conceptualised as a person's ability to execute different motor activities, including coordination of both fine (e.g.

manual dexterity and fine motor integration), and gross (e.g. static and dynamic balance, upper limb and bilateral coordination, speed and agility) motor skills (Henderson & Sugden, 1992; Bruininks & Bruininks, 2005).

Piek et al, (2006) report on the important implications of motor competence for different aspects of child and adolescent development, including the awareness that children with low motor competence are at increased risk of a variety of psychological difficulties and that poor motor competence is associated with overweight and obesity. Children and adolescents demonstrating lower motor competence have a significantly higher Body Mass Index (BMI) compared to those with high motor competence (Piek, Baynam & Barrett, 2006) and in addition, motor skill ability and static balance have been indicated as significant predictors of BMI, signifying that individuals with low motor competence have increased likelihood of compromised health-related fitness (Cantell, Crawford & Tish Doyle-Baker, 2008). A further study has shown BMI and waist circumference to be significant predictors for ability to perform Fundamental Motor Skills - run, vertical jump, throw, catch, kick, and strike (Oakley et al, 2004) again linking motor proficiency to weight status.

Cawley and Spiess (2008) reported that the association between obesity and motor skill attainment is stronger for boys than girls. Additionally, motor competence significantly impacts on the likelihood of a child participating in physical activity (Smyth & Anderson, 2000) which creates a negative spiralling effect for overweight and obese children with regards to participation in healthy lifestyle behaviours.

There are many motor skill assessment tools available in Australia and internationally, however the majority of these tools are expensive to purchase in the standardised kits and require a considerable financial outlay for each individual test form for every child. These tools also take a considerable amount of time to implement. For example, the Bruininks Oseretsky Test of Motor Proficiency - BOTMP and the Bruininks Oseretsky

Test of Motor Proficiency 2nd Edition - BOT2, both take approximately 60 minutes to fully administer and then an additional 30 minutes to score for each child.

Although standardised motor assessments are very appropriate for use in detailed physiotherapy assessment, these measures are not appropriate for inclusion in a screening tool. However, such assessment tools provide a gold standard reference for a number of individual measures that thought to be associated with overweight or obesity and these are investigated during this research program. Thus both the gold standard measure and those with potential for development to be included in the screening tool are described below.

2.14.1 BOT2 – Gold Standard Reference Measure for Motor

Performance-related Fitness

The Bruininks Oseretsky Test of Motor Proficiency - BOTMP (Bruininks, 1978) has been widely used as an internationally recognised gold standard tool for testing motor proficiency for many years in children aged 4.5 – 14.5 (Hattie & Edwards, 1987; Duger, Bumin, Uyanik et al, 1999; Hassan, 2001; Kambas & Aggeloussis, 2006). It has been used to determine reliability and the validity of other tests such as the Wood Motor Success Screening tool (Zhang, Zhang & Chen, 2004) and the Movement ABC (Croce, Horvat & McCarthy, 2001). However, the BOTMP is discontinued and has now been superseded by the Bruininks Oseretsky Test of Motor Proficiency, 2nd Edition (BOT2).

The BOT2 is also now an internationally recognised, valid and reliable measure of Motor Proficiency (Bruininks & Bruininks, 2005), that provides a comprehensive picture of overall motor development for children and youth aged 4.5 – 21 years. It includes eight subtest components:

- Fine Motor Precision—7 items (e.g., cutting out a circle, connecting dots)
- Fine Motor Integration—8 items (e.g., copying a star, copying a square)

- Manual Dexterity—5 items (e.g., transferring pennies, sorting cards, stringing blocks)
- Bilateral Coordination—7 items (e.g., tapping foot and finger, jumping jacks)
- Balance—9 items (e.g., walking forward on a line, standing on one leg on a balance beam)
- Running Speed and Agility—5 items (e.g., shuttle run, one-legged side hop)
- Upper-Limb Coordination—7 items (e.g., throwing a ball at a target, catching a tossed ball)
- Strength—5 items (e.g., standing long jump, sit-ups)

The BOT2 covers a broad compilation of fine and gross motor skills, providing composite scores, percentile ranks and achievement levels, in four motor areas and one comprehensive measure of overall motor proficiency:

- Fine Manual Control
- Manual Coordination
- Body Coordination
- Strength and Agility
- Total Motor Composite

The BOT2 has been independently validated against the BOTMP as well as another commonly used motor assessment tool, the Peabody Developmental Motor Scales, Second Edition - PDMS-2 (Folio & Fewell, 2000).

Bruininks and Bruininks (2005) in the development of the BOT2, validated the newly developed tool by testing 49 individuals ranging from 6 – 14 years of age with both the BOT2 and the BOTMP and then examining the relationships between the BOT2 subtest and Total Motor composite scores to the equivalent subtests and Battery Composite Scores of the BOTMP. The correlation between the Total Motor Composite of the BOT2 and the Battery Composite of the BOTMP was shown to be strong at 0.80.

Additionally, Folio and Fewell (2000) completed a study with thirty-eight 4 and 5 year olds which sought to investigate the relationship between BOT2 scores and those of the PDMS-2. The PDMS-2 was purported to also measure gross and fine motor proficiency for typically developing children as in the BOT2. In the Folio and Fewell (2000) study both tools were administered with each of the children and the correlation between the Total Motor Composite of the BOT2 and the Total Motor Quotient of the PDMS-2 was again found to be strong at 0.73 (Folio et al, 2000).

Although the BOT2 is a highly regarded assessment tool for investigating motor proficiency in clinical settings throughout Australia and internationally, it has a number of barriers for use in the broader community as part of a screening protocol (Peerlings, 2007):

- It is considered by many to only be obtainable by medical and paramedical professions, and even then it is a costly tool to purchase and administer for each individual child.
- Because of the adaptation of some items a more thorough training is required ensuring that only professions with education in movement based skills are able to administer the test.
- A large open space (18 metres) is required for the test setting.
- For some of the younger children the time required to complete the test is too long (>60 minutes), so it is recommended to spread the assessment over two test sessions which decreases the likelihood of it being administered in the first place.
- It is an expensive tool for clinical use (approximately \$2500 per test kit and \$8 per additional test form that is required for each individual child).
- It is considered a gold standard, thorough and detailed motor proficiency assessment for use by physiotherapists, occupational therapists or PE teachers and other trained professionals and is therefore not suitable for use as a screening tool.

Whilst the above mentioned points are considered barriers for use of the BOT2 as a screening tool, the strength of the relationships demonstrated by Bruininks and Bruininks (2005) and Folio and Fewell (2000) provides evidence that the BOT2 is a valid tool for assessing the motor proficiency of children. For this reason the BOT2 has been selected as the gold standard measure in this research program to use as a reference for the validation study of the newly developed motor performance-related fitness measure (SAMS) to be included in the KidFit Screening Tool.

The BOT2 was used in Chapter 5 to determine if any relationship existed between BOT2 subtests and other health or motor performance-related fitness measures that had not previously been included in the screening tool.

2.14.2 Balance measures

Balance is a motor skill related component of physical fitness (Howley, 2001) and reduced balance has been previously associated with overweight and obesity in children. D'Hondt et al, (2009) in a study of one hundred and seventeen, 5 to 10 year old children, found that BMI was negatively correlated to both static and dynamic balance and accounted for 20% of variance for balance-related tasks performed by children. As obese children have significantly poorer performance in static balance tasks, particularly when required to stand on one leg (Deforche et al, 2009) a single leg stance (SLS) balance task was included in the suite of tests for investigation in this study program. The balance task has two variations and is a timed test which requires the child to stand on 1 leg (dominant stance leg, i.e. non kicking leg), with eyes open (SLSEO), hands on hips and knee bent between 45 and 90 degrees for up to one minute. The task is then repeated with eyes closed (SLSEC).

2.14.3 Development of the Speed and Agility Motor Screen (SAMS) as a measure of Coordination, Speed, Agility and Balance

Coordination can be divided into upper limb coordination and bilateral coordination tasks (Bruininks & Bruininks, 2005). Many upper limb coordination tasks involve object control or ball skills. As previous research (Oakley et al, 2004; Southall, Oakley & Steele, 2004) has demonstrated that body composition is poorly correlated with ball skills (i.e. kicking, forehand striking, catching and throwing), an upper limb coordination task has not been included in the suit of measures selected for this research program, other than those included in the BOT2.

Overweight and obese children have been shown to perform worse than non-obese children on muscular endurance tasks (Chen et al, 2006). Many muscular endurance tasks involve repetitive movements requiring whole body coordination, speed and agility, rather than pure muscular strength (e.g. sit-ups and push-ups). Gross-motor proficiency typically includes measures of balance, coordination, strength, speed and agility (Bruininks & Bruininks, 2005) and has been shown to significantly impact upon the likelihood of participation in physical activity (Smyth & Anderson, 2000), overall performance on cardiovascular fitness tests (Hands & Larkin, 2006; Cairney, Hay, Faught et al, 2007) and the extent of excessive weight and obesity (Faught, Hay, Cairney & Flouris, 2005). For these reasons it was deemed important to include in the screening tool a measure of motor proficiency that was quick and easy to administer. The Speed and Agility Motor Screen (SAMS) was designed for this purpose and is thought to include motor performance fitness components of speed and agility, core strength, whole body coordination and balance. These components are known to individually challenge overweight and obese children (Haga, 2009). The SAMS is a timed test while the child moves from standing with hands by side, to laying prone with hands above head and feet together, then rolling as a log 360 degrees, standing up and performing a two-stage jumping jack (star jump).

During the research program, the SAMS will be investigated for reliability and validity as a motor performance-related fitness measure against similar motor performance fitness measures (sub-tests) in the gold standard reference (BOT2). These comparison sub tests on the BOT2 include bilateral coordination, body coordination, running speed and agility and strength. Associations between the SAMS and other health and performance-related fitness measures, such as WC and BMI, will also be investigated to determine if the SAMS is a valid and suitable tool for inclusion in the KidFit Screening Tool.

2.15 Screening Tests – Points for Consideration in Tool Development

The application of screening tests is common in many domains of health and development and have been used for many decades as a means for identifying children with various developmental delays. Paediatric screening tests are designed to identify children who are at risk for developmental delays or disorders in a specific area (e.g. motor delay / disorder) and who may need further assessment to establish a diagnosis or cause for observed impairments (Meisels, 1988). For screening tests to be useful, they should be brief, easy to use and possess good psychometric properties (e.g. reliability, validity and accuracy) so that the results can be trusted and will be used to direct appropriate children to further assessment and subsequent intervention as needed. Although many screening tests are administered to large populations to identify an often small number of people with a condition, the KidFit Screening Tool could be applied to children when concerns exist about a child's motor proficiency when health concerns are already apparent. The KidFit Screening Tool could be applied to determine if further assessment of motor proficiency is warranted and guide referral processes to specialised services.

A common concern with screening tools is the number of “missed” cases or the high rates of false positive diagnoses. In order to address these concerns when developing a screening tool, it is critical to assess the sensitivity and specificity of the tool, so that

the overall accuracy of the tool can be determined. Sensitivity refers to the percentage of children who are correctly identified as having the condition/s they are being screened for (true positives). A screening test with low sensitivity is likely to miss many children who have the condition being screened for (false negatives). Sensitivity could perhaps be the most important characteristic for the KidFit Screening Tool because if the sensitivity is low, it will miss children who require further investigation of their motor proficiency as a possible contributor to their poor health-related fitness or inactivity. Specificity refers to the percentage of children who are correctly identified as not having the condition they are being screened for (true negatives). A test with a low specificity is likely to incorrectly identify children as having a problem when they do not (false positives). Knowledge of the sensitivity and specificity rates allow the predictive values of the test to be determined and an accuracy value for the screening test to be established. These values are critical for deciding on the usefulness and trustworthiness of a screening tool. If PE teachers, coaches or health professionals were to spend their valuable time applying a screening tool to children for any purpose they should expect to be able to trust the results to a high degree and be able to use the results to assist with making decisions about referral to specialised services for detailed assessment of the developmental area in question.

A final point for consideration in the development of any screening tool is how well the sample used in the study represents the sample it is intended for use with. It is therefore critical to include children in this study with a diverse range of motor proficiency and fitness levels and to monitor the participant sampling for bias towards particular populations throughout each of the studies in this doctoral research.

2.16 Implications for Test Inclusion – the basis for a series of reliability and validity studies to support inclusion of measures in the KidFit Screening Tool

A review of the relevant literature assisted with selection of a number of health and motor performance-related fitness measures for inclusion in the proposed screening tool for piloting in the early stages of the research program. In addition to the newly designed measures, the selected gold standard reference measures will be used to provide a benchmark for development of simpler clinical measures. This research program seeks to determine the reliability and validity of the newly designed measures against the selected reference measures. As the overarching objective of this doctoral research is to develop an accurate tool (KidFit Screening Tool) for identifying children with poor health and/or motor performance-related fitness (including overweight and obese children) the sensitivity and specificity of the refined KidFit Screening Tool will also be determined. The sensitivity and specificity values will allow the accuracy of the KidFit Screening Tool to be established so that users of the tool can make informed decisions about the usefulness and trustworthiness of the results to guide their decisions about referring children to specialised services.

CHAPTER 3.

CHILD OBESITY SERVICE PROVISION: A CROSS SECTIONAL SURVEY OF PHYSIOTHERAPY PRACTICE TRENDS AND PROFESSIONAL NEEDS

3.1 PRELUDE

This national survey of physiotherapists working with children, was the second step in the 'needs assessment' (Stage 1) for the development of a tool designed for screening the health and motor performance-related fitness of children. Specifically the survey data provides a profile of existing physiotherapy practices used, and services available for overweight and obese children and their families. The results assisted with developing an understanding of the perceived needs of physiotherapists if they are to work with children who are overweight or obese. Although ethical approval was granted for undertaking a focus group with survey participants if they consented (See Appendix 13), this step was not undertaken due to nil participants consenting to this process. At the time of this thesis submission this study was in review with the Australian Journal of Primary Health. This chapter represents the study works prior to the review process by this journal. To review the published (and fully edited) version of this chapter please access the following publication:

Milne N, Low Choy N, Leong G, Hughes R, Hing W. (2015). Child obesity service provision: a cross sectional survey of physiotherapy practice trends and professional needs. *Australian Journal of Primary Health*, 1-7. <http://dx.doi.org/10.1071/PY14101>

The analysis and interpretation of the results from this survey, in addition to the information sourced in the literature review (Chapter 2), guided the development of, and rationale for the KidFit Screening Tool. Specifically, this study assisted with

contextualising the issue of childhood overweight and obesity for the physiotherapy profession and identified the needs of physiotherapists if they are to engage further with assessment and intervention for overweight and obese children and their families.

3.2 ABSTRACT

This study explored current physiotherapy practice trends for management of children who are overweight or obese. The professional needs of physiotherapists working with this population were also assessed, including the perceived need for physiotherapy clinical guidelines for prevention and management of children with obesity. A cross-sectional survey design was employed, with questionnaires purposefully distributed through 13 key physiotherapy services throughout Australia. Snowball sampling resulted in completed questionnaires from 64 physiotherapists who provided services to children. Half (n=33, 52%) of respondents provided services specifically to overweight or obese children. Of those providing services, a quarter had prior training specific to working with this population. Most used multi-disciplinary models (n=16, 76%) and provided under 5-hours of obesity-related services each week (n=29, 88%). Half (n=16, 49%) used Body-Mass-Index as an outcome measure but more (n=25, 76%) used body-weight. Only 14 (42%) assessed motor-skills. The majority of respondents (n=57, 89%) indicated a need for physiotherapy guidelines to best manage overweight and obese children. Professional development priorities included; 'Educating children and families', 'Assessment methods' and 'Exercise prescription' for overweight and obese children. This data provides workforce intelligence to guide future professional training and inform development of clinical guidelines for physiotherapists in prevention and management of children with obesity and related chronic disease.

3.3 SUMMARY STATEMENT

What is known about the topic?

- Childhood overweight/obesity is a global health concern and physiotherapists have significant potential roles in obesity management, yet limited clinical time is allocated by physiotherapists to overweight or obese children.

What does this paper add?

- This survey data provides information about the perceived needs of physiotherapists to enhance physiotherapy service delivery to overweight and obese children.

3.4 INTRODUCTION

Australian physiotherapists are primary contact practitioners who, as part of core competency professional-entry training, are skilled to assess, diagnose and treat children and adults who have or are at risk of movement-related disorders. This includes disorders associated with underlying cardiorespiratory, musculoskeletal and neurodevelopmental disease. The educational background of many recently trained physiotherapists now comprises exercise science, which includes the development of knowledge and skills in prevention and management of chronic disease, with exercise prescription and fitness testing being major components. In view of this educational background, and considering physiotherapists are further trained to enhance children's motor proficiency through play-based assessment and treatment, it appears that physiotherapists have a unique skill set to offer in making a significant contribution to the management of children who are overweight or obese.

Childhood overweight and obesity has both short and long term economic, health, movement and education related consequences (Access Economics 2008; Colagiuri, Lee, Colagiuri et al, 2010; Dietz 1998; Power, Lake & Cole, 1997; WHO 1998; Oakley, Booth, Hardy et al, 2008). Specifically, obesity-related motor incompetence in childhood has been linked to poor health and fitness in children, adolescents and adults (Cantell, Crawford & Tish Doyle-Baker, 2008) as well as poor self-perception,

poor self-worth (Piek, Baynam & Barrett, 2006) and reduced academic achievement (Castelli, Hillman, Buck et al, 2007). Obesity-related motor incompetence is an area that is particularly relevant to physiotherapists as it may impact upon a child's ability to take up and fully participate in physical activity. Physical activity reduces cardiovascular risk factors, likelihood of insulin resistance and Type-2-Diabetes-Mellitus (T2DM), protects against some types of cancer and strengthens the musculoskeletal system ((Australian Institute of Health and Welfare (AIHW) 2009; National Health and Medical Research Council (NHMRC) 2003; Oakley, Booth, Hardy et al, 2008). In addition, physical activity also improves children's psychosocial well-being by reducing symptoms of anxiety and depression as well as reducing problematic behaviour (Hills, King & Armstrong, 2007; Kirkcaldy, Shephard & Siefen, 2002). Moreover, motor proficiency has been identified as an important determinant of physical activity in children (Wrotniak, Epstein, Dorn et al, 2006) and should be a factor that is considered when planning assessment and intervention of children who are overweight or obese.

The recently released NHMRC Clinical Practice Guidelines for the Management of Overweight and Obesity in Adults, Adolescents and Children in Australia (NHMRC 2013), outlines the main points for assessment of children and adolescents who are overweight or obese from a multi-disciplinary perspective. Included, are two points that are directly relevant to physiotherapists. Firstly, gait, problems with feet, hips and knees, difficulties with balance and coordination; and secondly, hip and knee joint pain (NHMRC 2013). Although clearly listed, there is no detail within the NHMRC guidelines to guide the objective and valid assessment of these impairments, such as the type and timing of assessments and outcome measures to use that may enhance clinicians understanding of why an obese child is unable to be physically active (e.g. motor development assessments). Importantly, minimal detail is provided on how to go about making children 'physically active' in a developmentally and ability appropriate manner (e.g. enhancing the child's motor proficiency through play-based interventions to enable physical activity in their daily events such as lunchtime play).

Currently, limited data is available to infer obesity-related physiotherapy practice trends, tools used or barriers to service provision for this population of children in Australia. There is no available data outlining self-perceived training needs of physiotherapists for enhancing practices with overweight or obese children. Therefore, the purpose of the present study was to: a) explore current physiotherapy workforce practices in relation to the management of children who are overweight or obese, and b) identify the training and professional development needs of physiotherapists, including the perceived need for physiotherapy clinical guidelines to best manage overweight and obese children.

3.5 METHODS

Participants

With the assistance of designated personnel in existing state departments, databases of physiotherapists servicing children in general, were used to develop an initial sample frame for distribution of the questionnaire. Questionnaires were distributed through 13 key paediatric physiotherapists who were spread across a mix of health, education, disability and private sector services throughout Australia. Each mailed questionnaire was accompanied with instructions to copy and forward to other known paediatric physiotherapists; a technique known as snowball sampling (Grbich, 1999). Additionally, the survey was advertised (with an on-line link to the survey) through the Australian Physiotherapy Association (APA) - National Paediatric Group (NPG) Newsletter, which was distributed to all APA members who were registered with the NPG at the time. Physiotherapists working with children in a range of clinical settings (health, education, disability and private sector), with varied degrees of training and experience, across Australia were invited to participate in the survey. Exclusion criteria included physiotherapists not providing services to children. This sampling method resulted in completed questionnaires from 64 physiotherapists who provided services to children.

Design

A cross-sectional survey design using self-administered questionnaires was employed. The survey tool was developed in three phases: Firstly, the Queensland Paediatric Obesity Working Group physiotherapists were consulted to identify key questions relevant to physiotherapy practice in this context. Secondly, the drafted questionnaire was piloted by five generalist physiotherapists and individual debriefing was used to assess question ambiguity. Finally, the questionnaire was modified to reflect feedback pertaining to knowledge of prevalence of overweight and obesity, prior to distribution to potential study participants.

Tools

The survey questionnaire consisted of eight sections: 1. Demographics, 2. Physiotherapy service provision, 3. Referral sources and waiting times, 4. Interventions, 5. Outcome measures and assessment tools, 6. Training and professional development, 7. Utilisation and development of clinical guidelines and/or departmental policies, and 8. Knowledge of prevalence of overweight and obesity (see Appendix 12). Twenty-five closed ended questions were used. One open-ended question relating to potential content themes for inclusion in guidelines for physiotherapists was included. Distributed questionnaires included a covering letter and explanatory statement, inviting physiotherapists working with children in general (not just obese children) to complete the questionnaire. Ethical approval was granted by Bond University Human Research Ethics Committee.

Data analysis

All quantitative data were entered into SPSS Statistics software, Version 21 (IBM Corp, Amonk, NY, USA) for storage and analysis. Descriptive statistics were used to present a demographic profile of participants and to compare response distributions for all closed ended questions. Quantative data was presented as count scores. Chi-square analysis was used to compare response distributions for multiple-response scale

questions by service provider categories (Hospital-based v's Non-Hospital positions). In order to assess the potential for sampling bias, Chi-square goodness of fit analysis was undertaken to investigate if the survey population differed from the reference population (APA-NPG membership). A p -value of < 0.05 was used as a significance cut-off. Open ended qualitative question data was thematically analysed using open coding methods to develop themes of inclusion regarding content for clinical guidelines.

3.6 RESULTS

Flow of participants through the study

A total of 64 questionnaires were completed. Due to the nature of survey distribution the total sample frame is unable to be accurately identified. Table 3.1 details the demographic profile of survey participants. Most respondents were female which is similar to the membership of the APA-NPG ($\chi^2 = 1.07$, $p = 0.30$). More than half of participants were 30 years or older, similar to APA-NPG reference data ($\chi^2 = 1.39$, $p = 0.24$) with at least 10 years of physiotherapy experience. The majority nominated diploma or bachelor degree as their highest level of physiotherapy qualification, which was significantly lower than those nominating the same qualification levels in the APA-NPG ($\chi^2 = 12.93$, $p = 0.00$). Queensland (QLD) and New South Wales (NSW) physiotherapists were the dominant respondents, accounting for more than 80% of the total sample. The APA-NPG had only 50% of members working in QLD or NSW at the time of the survey indicating that the sample significantly differed to the geographical distribution of national group members ($\chi^2 = 25.0$, $p = 0.00$). Most of the respondents worked for the public sector, which was a significantly higher proportion ($\chi^2 = 11.27$, $p = 0.001$) than for members of the APA-NPG.

Table 3.1 Characteristics of survey respondents

Characteristics	Service Providers							Difference to APA-NPG Data (n=411) p-value
	Total (n=64)	Hospital (n=27)	Non – Hospital (n=37)	Community Health (n=14)	Disability (n=8)	Education (n=7)	Others (n=8)	
Female, number (%)	58 (91)	25 (93)	33 (89)	14 (100)	8 (100)	5 (71)	6 (75)	-
Male, number (%)	6 (9)	2 (7)	4 (11)	0	0	2 (29)	2 (25)	0.30
State, number (%)								
Queensland	26 (41)	10 (37)	16 (43)	6 (43)	1 (13)	4 (57)	5 (63)	0.00*
New South Wales	26 (41)	12 (44)	14 (38)	4 (29)	7 (88)	2 (29)	2 (25)	
Victoria	5 (8)	2 (7)	3 (8)	1 (7)	-	1 (14)	1 (13)	
Western Australia	2 (3)	2 (7)	-	-	-	-	-	
South Australia	3 (5)	-	3 (8)	2 (14)	-	-	1 (13)	
Tasmania	1 (2)	1 (4)	-	-	-	-	-	
Not Specified	1 (2)	-	1 (3)	-	-	-	1 (13)	
Age range, years (%)								
20-30	19 (3)	8 (30)	11 (30)	5 (36)	1 (13)	3 (43)	2 (25)	0.24
30-40	14 (22)	9 (33)	5 (14)	1 (7)	1 (13)	1 (14)	2 (25)	
40-50	16 (25)	6 (22)	10 (27)	4 (29)	1 (13)	3 (43)	2 (25)	
50-64	15 (23)	4 (15)	11 (30)	4 (29)	4 (50)	1 (14)	2 (25)	
64+	-	-	-	-	-	-	-	
Physiotherapy practice years (%)								
Less than 2	6 (9)	1 (4)	5 (14)	1 (7)	1 (13)	2 (29)	1 (13)	-
2-5	5 (8)	4 (15)	1 (3)	-	-	-	1 (13)	
5-10	16 (25)	8 (30)	8 (57)	4 (29)	2 (25)	1 (14)	1 (13)	
10-15	10 (16)	6 (22)	4 (11)	1 (7)	-	2 (29)	1 (13)	
More than 15	27 (42)	8 (30)	19 (51)	8 (57)	5 (63)	2 (29)	4 (50)	
Highest PT Entry Level Qualification (%)								
Diploma	7 (11)	4 (15)	3 (8)	1 (7)	2 (25)	-	-	0.00*
Bachelor	38 (59)	14 (2)	24 (65)	11 (79)	6 (75)	4 (57)	3 (38)	
Masters	15 (23)	9 (33)	6 (16)	2 (14)	-	1 (14)	3 (38)	
Doctor	4 (6)	-	4 (11)	-	-	2 (29)	2 (25)	

*Chi-square goodness of fit analysis between survey and APA-NPG data.

Significant difference: * $p < 0.05$

APA-NPG – Australian Physiotherapy Association, National Paediatric Group, PT – Physiotherapist.

Current service provision to children and adolescents with overweight or obesity.

Although all respondents provided services to children, just under half (n=31, 48%) indicated that they did not provide services to overweight or obese children. Two main reasons were provided: 'This population is not prioritized by our service' (n=17, 55%) and 'Not enough physiotherapists to service this non-acute need' (n=9, 29%). Table 3.2 outlines the details of physiotherapy service provision to overweight and obese children by survey respondents. For those who provided services to overweight and obese children; the majority implemented multi-disciplinary models of care. Most respondents (n=29, 88%) provided services less than 5-hours per week. One third provided services in a hospital environment, with the remaining services being provided in the community. With regards to waiting times, 12 (40%) provided the first service within 1-month of referral and only two respondents (6%) indicated waiting times over 6 months. Direct (face-to-face) group education and direct (face-to-face) group exercise were the dominant forms of intervention provided by physiotherapists, regardless of service environment (hospital or community). With regards to outcome measures and assessment tools, almost half of respondents (n=16, 49%) used BMI but more (n=25, 76%) used body-weight. Only 14 (42%), assessed motor skills. Significantly more physiotherapists in the non-hospital environment used the Goal Attainment Scale (GAS) as an outcome measure compared to those working in the hospital environment ($\chi^2 = 3.98$, $p = 0.045$).

Training and professional development needs

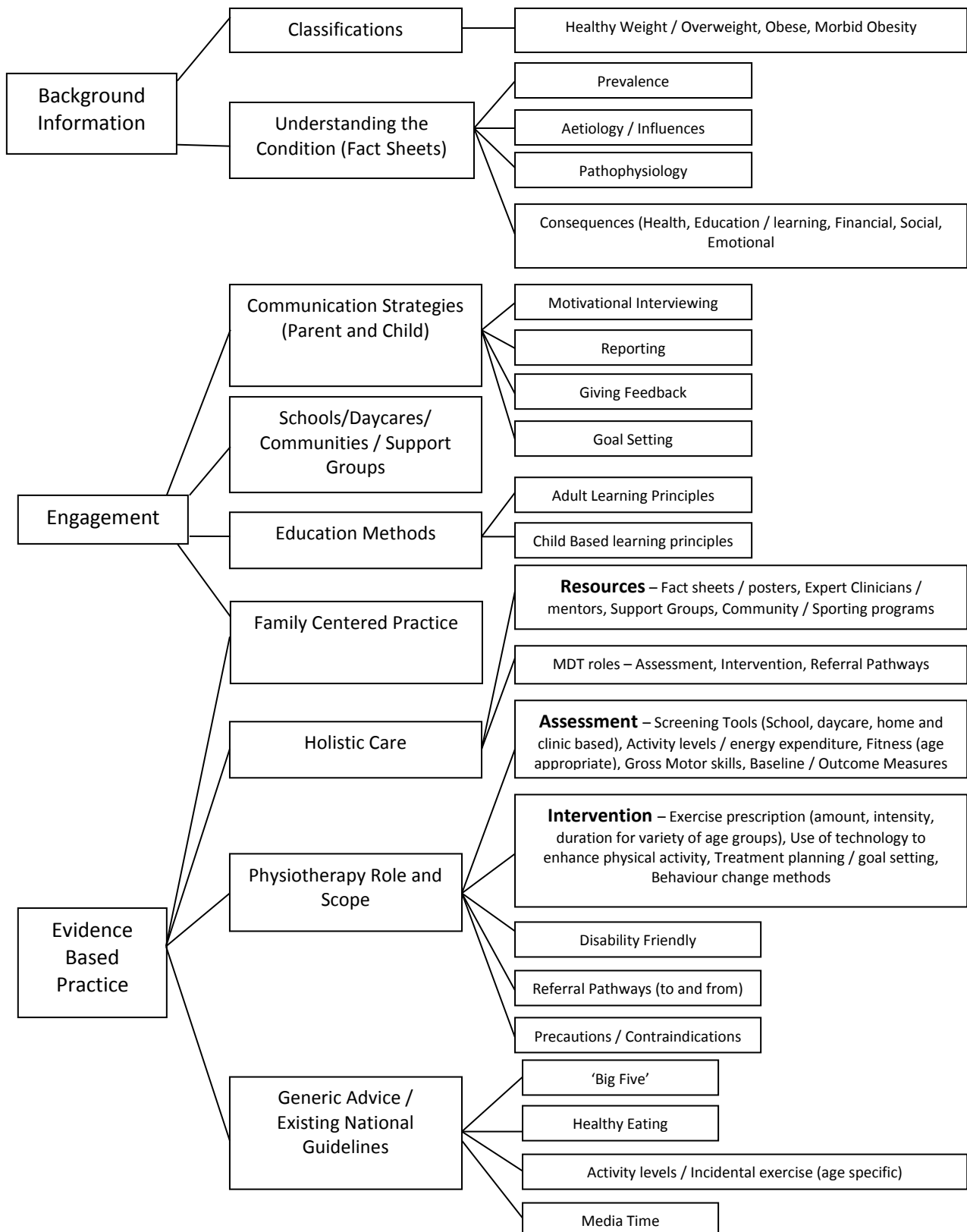
The top three professional development priorities included; 'How to educate children and their families' (n=46, 72%), 'Assessment methods for overweight and obese children – including baseline anthropometric measurement and appropriate outcome measures' (n=43, 67%) and 'Exercise prescription in children' (n=39, 61%). Only a quarter (n=16, 25%) had prior training (formal or informal) relating to working with overweight or obese children with only 31 (49%) able to accurately indicate the extent of overweight and obesity in Australian children and far less (n=16, 25%) able to accurately indicate the rate of adult overweight and obesity.

Table 3.2 Physiotherapy service provision to overweight and obese children

Service Provision Component	Service Providers		
	Total (n=33)	Hospital (n=11)	Non – Hospital (n=22)
Practice in MD Team number (%)	25 (76)	9 (82)	16 (73)
Members of MD Team (3 most frequent responses) number (%)	Dietitian 19 (58) Doctors 16 (49) OT 16 (49)	Doctors 9 (82) Nurses 9 (82) Dietitian 8 (73)	Dietitian 11 (50) OT 11 (50) Doctors 7 (32)
Referral Base (3 most frequent responses) number (%)	Paediatrician 16 (49) GP 12 (36) Parent / Carer 11 (33)	Paediatrician 6 (55) Orthopaedic Surgeon 5 (45) Other Med. Specialist 4 (36)	Parents / Carers 11 (50) GP 11 (50) Schools / Daycare 10 (45) Paediatrician 10 (45)
Service Models, number (%)			
Direct Education	15 (46)	5 (45)	10 (45)
Direct Exercise	15 (46)	4 (36)	11 (50)
Direct Group Education	28 (85)	10 (91)	18 (82)
Direct Group Exercise	28 (85)	9 (82)	19 (86)
Assisted Goal Setting	21 (64)	6 (55)	15 (68)
Physio School Based	22 (67)	5 (45)	17 (77)
Indirect Education	9 (27)	1 (9)	8 (36)
Indirect Program Development	9 (27)	2 (18)	7 (32)
MDT Assessment and Review	23 (70)	8 (73)	15 (68)

MD Team – Multidisciplinary Team, OT – Occupational Therapists, GP – General Practitioner.

Figure 3.1 Suggested content area (themes) for inclusion in physiotherapy clinical practice guidelines for working with children who are overweight or obese



Practice guidance frameworks

Only 14 (22%) survey respondents indicated they worked under guiding policies, position statements or clinical guidelines related to working with children who are overweight or obese. There was majority support (n=57, 89%) for the development of physiotherapy guidelines to assist physiotherapists to best manage children who are overweight or obese. Twenty-six respondents (41%) provided comments regarding the inclusion of themes and content for clinical practice guidelines as summarized in Figure 3.1. The most common suggested theme for inclusion in the clinical guidelines was “physiotherapy role and scope”.

3.7 DISCUSSION

This study is the first in Australia to assess the workforce practices and professional needs of physiotherapists in relation to service provision for overweight and obese children. With the sustained high rates, earlier onset and increased severity of overweight and obesity amongst Australian children, one may reasonably predict that there will be a significant increase in complicated health conditions associated with child obesity in the foreseeable future. This predicted growth in demand for obesity-related health service provision requires strategic and needs-based workforce development. In order to build future workforce capacity, capable of responding to obesity-related service requirements, intelligence-based workforce development systems need to be used (Hughes, 2004). To do this, workforce practices must first be assessed and then this intelligence can be used to plan approaches to overcoming workforce problems. To that end, the findings of this study provide insights that are relevant to improving the capacity of physiotherapists to realize potential service contributions to management of overweight and obese children and their families.

Our survey revealed that only a small number of physiotherapy participants provided services to overweight and obese children across Australia. For those who did, they typically provided their service within a multidisciplinary team but very little clinical

time was allocated to this population of children. The limited service provision could be associated with the following factors: 1. Low referral rates as a consequence of the physiotherapy profession not defining or marketing its role in the management of overweight and obese children; 2. A lack of confidence in physiotherapists applying their skill set for assessment of motor proficiency and enhancing performance-related fitness, as contributing factors for physical inactivity in children who are overweight or obese, and 3. The service model. Predominant reasons for physiotherapists not providing services at all to overweight or obese children appear to be more in keeping with individual workplace service models and policy (e.g. '*...not prioritized by service*') and a lack of workforce leadership in this area. This suggests a deficiency of employer and government sector support for physiotherapy services in this clinical area or a lack of awareness of the unique skill set that physiotherapists could provide to meet the needs of these children. Further investigation is required to explore this issue, to determine if this is due to limited employer and government sector awareness for the skill set that physiotherapists have to meet the needs of overweight and obese children, or if it is simply due to employers having higher priority needs (i.e. acute services) to be met with limited resources.

In terms of assessment tools and outcome measures used by physiotherapists when working with overweight and obese children, body-weight, more so than BMI, was used. This indicates either a limited awareness by physiotherapists of appropriate assessment tools for diagnosis of childhood overweight and obesity or, a lack of application for the interprofessional clinical guidelines (NHMRC, 2003; NHMRC, 2013) related to working with this population. Furthermore, less than half of respondents who provided services to overweight and obese children indicated that they assessed motor skills. This could be partially explained by the service environment (hospital versus community). For example, the child may have been admitted for acute care needs (e.g. slipped femoral epiphysis) rather than direct investigation or intervention of obesity-related conditions. In such circumstances it would not be appropriate to assess motor skills. Additionally hospitals do not always have access to the space and

equipment to formally assess motor skills and staff in acute care settings may not have the time to do so, with competing acute caseloads.

There is strong evidence to suggest that increased BMI is associated with reduced ability to perform fundamental motor skills (Oakley et al, 2004) and that motor skills and static balance are significant predictors of BMI (Cantell et al, 2008). Furthermore, the World Confederation for Physical Therapy (WCPT, 2013) advocates the role and scope of the physical therapist to be about: developing, maintaining and restoring maximum movement and functional ability (including motor proficiency) across the lifespan when movement and function are threatened or impaired by disease, disorders, conditions or environmental factors. This includes children with obesity. So, although the findings of this study show that motor skill assessment is limited for this clinical population, physiotherapists should be suitably trained and well positioned, to implement their unique skill set of assessing children's motor proficiency to determine if it is a contributing factor to their overweight or obesity.

This survey found that only a quarter of participants had undertaken specific training related to overweight or obesity and that participants had a relatively poor understanding of Australian obesity prevalence. It is therefore not surprising that participants overwhelmingly expressed a need for professional development and physiotherapy clinical guidelines to assist them to best manage overweight and obese children. These study findings suggest that attention should be directed towards workforce development strategies that aim to improve knowledge and application of skills in this clinical area using the intelligence gained in this survey. Specific strategies could include targeted university curriculum to better prepare the future workforce and professional development around child obesity for both current physiotherapy service providers and public health policy makers.

3.8 LIMITATIONS

Despite the fact that not all Australian physiotherapists are members of the APA, the best reference data accessible for comparison to the present survey was the 2011 APA-NPG membership data. The methodological issue of having limited information systems to enumerate workforce and compare data is consistent with issues outlined in broader public health workforce research (Gebbie, 2000; Gebbie & Merrill 2001). It is not known how representative the study sample is of all Australian physiotherapists working with children and this presents as a limitation to the study. Although, age and gender characteristics of survey respondents were consistent with APA-NPG membership data, our survey has a small but significant sampling bias towards physiotherapists with a Diploma or Bachelor degree as their highest professional qualification. Future research should address the aforementioned methodological issues (data collection methodology and appropriate sample size). Further research is required to investigate if the rates of service provision to overweight and obese children would be higher for physiotherapists with a graduate-entry qualification (i.e. entry level Master or entry level Doctor qualifications to practice as a physiotherapist) where exercise science is their primary degree with obesity and chronic disease assessment and management commonly covered in curriculum.

3.9 CONCLUSIONS

This paper provides intelligence to suggest that physiotherapists are currently providing little input into the management of children who are overweight or obese, despite having a skill-set that is appropriate to work with this population. Findings from this study can inform both public health and physiotherapy-specific workforce development strategies to enhance overall competency in the important clinical area of child obesity. In particular, professional development needs amongst the current physiotherapy workforce have been identified. In line with this information new entry level curricula could be developed to ensure the future workforce is prepared to manage children who are obese or overweight. Furthermore this study provides key

themes for inclusion in physiotherapy clinical guidelines to better prepare physiotherapists to work with overweight and obese children and their families. Caution should be exercised to ensure that development of such guidelines is not restricted to the needs identified in this survey and should be coupled with evidence-based practice applied across the health, development, disability and education sectors.

The potential contribution of physiotherapists as primary contact practitioners in obesity prevention and management is unlikely to be realized without further workforce development effort, including practitioner up-skilling, curriculum changes and development of clinical guidelines to inform physiotherapy practice.

3.10 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 4.

DEVELOPMENT OF A TOOL FOR SCREENING THE HEALTH AND PERFORMANCE-RELATED FITNESS OF CHILDREN: INTER-TESTER RELIABILITY OF ANTHROPOMETRIC AND MOTOR FITNESS MEASURES

4.1 PRELUDE

In order to collect data with children in schools for this doctoral research, the approved protocols required a minimum of two persons to be present with the child, whom had undergone working with children checks and were first aid trained. For this reason there were always two people involved with the data collection for this study. It was therefore imperative that there was a standardised process for collecting the data and that the inter tester reliability of those involved with collecting the anthropometric and motor fitness measures was assessed. This study served as a quality insurance step to ensure consistency between testers for data collection in this doctoral research. There was no requirement to reassess the psychometric properties of the standardised assessment tools (BOT2, VO₂peak testing, 20m MSRT) as these had been previously validated and were widely used. As the testers for this study included physiotherapists (one of whom had extensive experience with collecting anthropometric and motor fitness measures) and PE teachers, this methodological step investigated if PE teachers could reliably collect anthropometric and motor fitness measures with children. Although this investigation of inter tester reliability is limited by small participant numbers, the findings support the notion that adequately trained PE teachers could assist with screening the health and motor performance-related fitness of children.

It should be noted that the study outlined in this chapter was completed as a preliminary step in this doctoral research and results were considered before further data collection occurred. This step assisted with refining the measures to be included in the KidFit Screening tool for future planned studies.

4.2 ABSTRACT

Aims: This study aimed to determine the inter-tester reliability of physiotherapists and PE teachers in the measurement of waist circumference, flexibility, balance, coordination, agility and fitness as a preliminary step in developing a tool for screening the health and performance-related fitness of children. An additional aim of this study was to determine if significant differences existed between waist circumference (WC) measures at the iliac crest (WC-IC) compared to those taken at the umbilicus (WC-U).

Methods: Participants included 14 school-aged children with a mean age of 10.08 years (5–16 years) with no known physical disability. Males (n=5) and females (n=9) participated. Five testers were involved with the study (two physiotherapists and three PE Teachers). Each tester had previous experience and training in assessment of motor ability in children. The measures for each child were recorded independently by each tester. Each tester was blinded to the results of other testers. Measures included waist circumference (cm) at iliac crest (WC-IC) and umbilicus (WC-U); upper limb flexibility (deg) test (ULFT); timed single leg stance (sec) eyes open (SLSEO) and eyes closed (SLSEC); the Speed and Agility Motor Screen (SAMS) (sec) and Modified Shuttle Test-Paeds (MSTP) (no) – 1 minute version.

Results: The absolute agreement between testers was very high with Cronbach's Alpha(CA) > 0.9 for each of the tests (CA WCIC=0.997; CA WCU=0.995; CA ULFT=0.903; CA SLSEO=0.999; CA SLSEC=0.999; CA SAMS=0.972; CA MSTP=0.996). Significant Intra-class Correlation Coefficients (ICCs) were determined for all measures with ICCs moderate for ULFT (ICC=0.650), high for the SAMS (ICC=0.876) and very high for all other tests (ICC=>0.9).

Conclusions: Physiotherapists and PE teachers demonstrated very high inter-tester reliability for most measures, supporting the notion that adequately trained PE teachers and physiotherapists could assist with screening the health and motor performance-related fitness of children to guide decisions about referral to specialised services for detailed assessment and pre-emptive interventions.

Key Words: Children, Overweight, Obesity, Screening, Anthropometric, Fitness, Motor Proficiency, Reliability.

4.3 INTRODUCTION

The prevalence of overweight and obesity has increased significantly over the past two decades with approximately 25% of Australian children now considered overweight or obese (Booth, Chey, Wake et al, 2003; Magarey, Daniels & Boulton, 2001). As approximately half of all Australian adults are overweight or obese (National Preventative Health Taskforce, 2008) and as weight status in young children is an important predictor of health related consequences in adulthood (Magarey, Daniels, Boulton, & Cockington, 2003; WHO, 1998; Dietz, 1998; Power, Lake & Cole, 1997), it is important to identify as early as possible, children who are at risk of or are overweight or obese. There is also a known link between health status and academic performance in children (Castelli, Hillman, Buck et al 2007).

Currently, a number of anthropometric tools are used to screen and assess children for overweight and obesity with BMI percentiles and BMI Z scores proving to be commonly used for classifying overweight and obese children in Australia. Although both of these measures have documented problems for use as standalone tools, they are useful for classifying children as overweight or obese but have limited ability to guide the referral and therapeutic process.

It is known that children and adolescents with lower motor competence have significantly higher BMIs compared to those with high motor competence (Cantell, Crawford & Tish Doyle-Baker, 2008). Motor skills and static balance are significant predictors of BMI, indicating that individuals with low motor competence have compromised health-related fitness (Cantell et al, 2008). BMI and waist circumference (WC) are significant predictors for ability to perform fundamental motor skills (run, vertical jump, throw, catch, kick, and strike) (Oakley, Booth & Chey, 2004). These studies highlight the need for a simple, motor test to screen children who are at risk of health and motor performance-related fitness deficits associated with overweight and obesity. These measures can potentially be used to guide and facilitate referral to suitable services for detailed assessment and therapeutic interventions.

It is proposed that the Speed and Agility Motor Screen (SAMS) be used for this purpose, as it is a single task with several elements that are thought to challenge speed, agility, balance and body coordination. For this test to be used in practice, reliability and validity studies are required. The main aim of this study was to determine the inter tester reliability of physiotherapists and PE teachers using a number of anthropometric and motor / fitness measures (including the SAMS) with children aged 5 – 16 years. An additional aim of this study was to determine if there were any significant differences between the WC measures taken at the iliac crest compared to those taken at the umbilicus. This study acted as a preliminary step in developing a tool for screening the health and performance-related fitness of children as both of these fitness components impact on a child's exercise capacity which is an independent predictor of all-cause mortality (Lee & Skerrett, 2001). The final version of the screening tool is intended to assist with making decisions about referral to specialised services, for detailed assessment and intervention for obesity-related motor incompetence, with the aim of preventing the onset of chronic disease.

4.4 METHODS

Participants

Participants were invited from a number of South East Queensland schools and included 14 school-aged children with a mean age of 10.08 years (5–16 years) with no known physical disability. Males (n=5) and females (n=9) participated. Five testers consented to participate in the study (2 physiotherapists and 3 PE teachers). Informed parent/legal guardian consent and child assent, in addition to a parent completed medical history form were obtained for all children who participated in the study.

Experimental Design

Each tester had previous experience and training in assessment of motor ability in children and was provided with an additional 2 hour training session in the application of each measure prior to the testing day. The chief investigator for this study delivered the instructions to the children participating in the study and the measures for each child were independently and simultaneously recorded by each tester at the time that the child completed the activity. Testers were blinded to the results of other testers.

All child participants were familiarised with the testing protocol before participating in the study. Measures included waist circumference (WC) which was measured to the nearest 0.5cm at iliac crest (WC-IC) and umbilicus (WC-U) using a 7mm wide flexible, inelastic tape measure; upper limb flexibility test (ULFT) (degrees), involving a standing isolated bilateral shoulder extension task (see Appendix 2 for further details); timed single leg stance eyes open (SLSEO) (sec) and eyes closed (SLSEC) (sec); the Speed and Agility Motor Screen (SAMS) (sec), which is a simple timed speed and agility test (see Chapter 7 for complete details on the SAMS) and the Modified Shuttle Test – Paeds (MSTP) (no.), which required the children to run a 10 metre track, pick up a bean bag and return to the start line as many times as they could over a defined time period (see Chapter 6 for complete details on the MSTP). See Appendix 2 - Data Collection Sheet with test explanations, for details on how to take the measures for each of the

aforementioned tests. Bond University Human Research Ethics Committee reviewed and approved the experimental protocol for the present study (RO1019).

Statistical Analysis

Means and standard deviations were calculated for each measure. Each waist circumference measure required the assessor to take two measures, which were averaged before calculating mean scores for the group. Reliability of assessors and absolute agreement between assessors was determined using Intra Class Correlations (ICCs) and Cronbach's Alpha respectively. The threshold for acceptance of tests in this study was set at CA: 0.8 and ICC: 0.7, ensuring all tests could achieve a high or very high level of intertester reliability and absolute agreement between assessors. Independent samples t tests were used to determine if there were significant differences between WC measures at the iliac crest (WC-IC) compared to those taken at the umbilicus (WC-U) so that decisions could be made about ruling out the more challenging measure of WC-IC with overweight and obese children. Statistics were analysed with SPSS for Windows (Version 20.0) with a significance level set at $p < 0.05$.

4.5 RESULTS

The mean of each of the measures were: WC-IC = 62.14 ± 1.91 cm; WC-U = 61.96 ± 1.86 cm; ULFT = 72 ± 8.12 degrees; SLSEO = 47.66 ± 17.86 s; SLSEC = 12.17 ± 10.41 s; SAMS = 4.43 ± 0.69 s; MSTP = 8.07 ± 1.0 bean bags. Independent samples t tests revealed no significant difference between the WC measures at the iliac crest compared to those taken at the umbilicus ($t = 0.067$, $DF = 26$, $p = 0.947$).

Inter-tester reliability and absolute agreement between testers was determined with Intraclass Correlation Coefficients (ICC's) and Cronbach's Alpha (CA) respectively and these results are detailed in Table 4.1. The absolute agreement between testers was very high with Cronbach's Alpha(CA) > 0.90 for each of the tests. Significant Intra-class Correlation Coefficients (ICCs) were determined for all measures with ICCs moderate

for ULFT (ICC= > 0.60), high for the SAMS (ICC= > 0.8) and very high for all other tests (ICC= > 0.9).

Table 4.1 Inter-tester reliability and absolute agreement between testers for anthropometric and motor performance-related fitness measures.

Measure	ICC	CA
Waist Circumference – Iliac Crest (WC-IC)	0.986*	0.997*
Waist Circumference – Umbilicus (WC-U)	0.977*	0.995*
Upper Limb Flexibility Test (ULTF)	0.650*	0.903*
Single Leg Stance – Eyes Open (SLSEO)	0.996*	0.999*
Single Leg Stance – Eyes Closed (SLSEC)	0.998*	0.999*
Speed and Agility Motor Screen (SAMS)	0.876*	0.972*
Modified Shuttle Test-Paeds (MSTP)	0.974*	0.996*

*Significance level set at $p < 0.01$.

4.6 DISCUSSION

Many overweight and obese children across all age ranges are presenting to community and hospital based physiotherapy clinics across Australia, with direct and indirect referrals from diverse sources. It is apparent that different models of assessment and intervention practices exist, many of which are group based and generic in nature (e.g. MEND program; (Sacher et al, 2010)). These may not best meet

the needs of children with regards to reducing the risk of developing chronic disease related to overweight or obesity as they may not address the underlying causes of a child's inactivity if it is related to motor incompetency. Developing a reliable and valid tool which can accurately screen the health and motor performance-related fitness of children and related conditions (i.e. overweight and obesity) may aid the referral process and assist health and education professionals to work collaboratively to tackle the public health crisis that childhood obesity presents. It may also help to ensure that children who will best benefit from targeted physiotherapy interventions to address motor incompetency will have their needs most appropriately met.

The main aim of this study was to determine the inter tester reliability of physiotherapists and PE teachers using a number of anthropometric and motor fitness measures (including the SAMS) with children aged 5 – 18 years. An additional aim of this study was to assess if significant differences existed between WC measures taken at the iliac crest compared to those taken at the umbilicus. This study was designed as a preliminary step in developing a tool for screening the health and motor performance-related fitness of children, specifically those who are overweight or obese.

With the absolute agreement and the reliability coefficients between testers being high to very high for each of the measures, with the exception of the Upper Limb Flexibility Test which was moderate, the primary aim of this study was addressed. These results ensure that each of the testers was adequately trained to implement the measures consistently, and that the measures were suitable inclusions on the Data Collection Sheet for further planned studies. The inadequate inter-tester reliability for the ULFT assisted to rule this measure out as a potential inclusion in the KidFit Screening Tool. It is likely that the inadequate inter-tester reliability was due to the extensive training required for goniometric measurements, whereas limited training was available for assessors in this study. If this measure was to be utilised by PE teachers, more specific training would be required in the area of goniometric

measurement and this is not likely to be taken up by PE teachers who largely have a hands-off policy to working with children. Additionally no significant difference was found between the WC measures taken at the iliac crest compared to those taken at the umbilicus. The WC measure taken at the umbilicus is an easier measure to take for those who do not possess good anatomical skills and it does not require palpation of the bony landmark which can be challenging in overweight and obese children. For this reason the WC measure at the iliac crest will be removed from the Data Collection Sheet and the WC measure at the umbilicus will be retained.

Magarey et al (2003) concluded their obesity-related study by suggesting that strategies for prevention of overweight including targeted interventions for preventing child overweight progressing to adult obesity are urgently required. This reliability study provided a preliminary step for creating a tool that will assist with referring children for detailed assessment and targeted interventions to improve their health and motor performance-related fitness.

4.7 LIMITATIONS

In this study, PE teachers and physiotherapists only were used to ascertain the inter-tester reliability of the measures to be used for further data collection. The sampling of testers for this study could have been extended to coaches and other health professionals (e.g. nurses). Additionally the number of testers was relatively small, however without compensation of their time, it was difficult to engage testers for longer than 1 day which also precluded this reliability study having more child participants. For this reason the sampling of testers was deemed appropriate to meet the aims of this study and to move forward with validating the newly designed measures.

4.8 CONCLUSIONS

This study demonstrates that adequately trained physiotherapists and PE teachers display very high inter-tester reliability for many anthropometric and motor fitness measures, supporting the notion that these health and education professionals could assist with screening the health and motor performance-related fitness of children. These results also suggest that the testers used for this study are suitably trained to participate in further data collection for this doctoral research.

Further studies are needed to investigate the validity of the measures included in this tool for screening children, including overweight and obese children, and to investigate the reliability of these measures with other health-related personnel implementing the measures. This would expand the utility of the tool and improve the possibilities for timely and accurate referral pathways to suitable health professionals.

4.9 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 5.

THE RELATIONSHIP BETWEEN CHILDREN'S MOTOR PROFICIENCY AND HEALTH-RELATED FITNESS

Milne N, Leong GM, Hing W. (2014). The relationship between children's motor proficiency and health-related fitness. *Journal of Paediatrics and Child Health*. In review.

3.1 PRELUDE

The research in this chapter contributed to Stage 2 in the development phase of the KidFit Screening Tool. This study investigated relationships between health and motor performance-related fitness measures using the gold standard measures selected for use in this doctoral research. Furthermore, this study determined if the relationships between these measures differed for children with poor motor proficiency compared to those with high motor proficiency. The results of this study guided decisions about inclusion and exclusion of the newly designed measures for the KidFit Screening Tool. For example, this study found that motor proficiency, particularly strength and speed and agility once corrected for age, could predict health status (BMI and WC) in children. This information supported the inclusion of the Speed and Agility Motor Screen (SAMS) in the KidFit Screening Tool. Furthermore, a strong predictive relationship between motor proficiency and cardiorespiratory fitness (VO₂peak) was observed in this study, supporting the addition of the newly designed more time efficient cardiorespiratory fitness measure (Modified Shuttle Test Paeds – MSTP) in the KidFit Screening Tool. These findings also reinforced the notion that motor incompetence should be investigated as a possible contributing factor for a child's poor health, which was the underlying premise for the development of the KidFit Screening Tool at the onset of this doctoral research. Proceeding chapters of this thesis investigate the psychometric properties (reliability, validity and accuracy) of the newly designed measures in the KidFit Screening Tool.

3.2 ABSTRACT

Aims: The overall purpose of this study was to examine the relationship between motor proficiency and health-related fitness in children. In addition the study aimed to determine if particular combinations of motor skills have a stronger relationship with individual health-related fitness measures.

Methods: Seventy-seven children (F:28, M:49) (Mean Age: 11.19±2.74 yr) participated in this cross-sectional study. Physical measures included: Motor proficiency (Bruininks-Oseretsky Test of Motor Proficiency, 2nd Edition), Body Mass Index (BMI), waist circumference (WC), blood pressure (BP), heart rate (HR), VO₂peak (mL/kg/min). Relationships between health-related measures and motor proficiency were investigated using Pearson's correlations and multiple regression analysis.

Results: After factoring in age; motor proficiency as a combined total score, had a strong negative relationship with the health-related fitness measures of BMI ($r^2 = 0.62$, $p < 0.001$) and waist circumference ($r^2 = 0.72$, $p < 0.001$) and a strong positive relationship with VO₂peak ($r = 0.78$, $p = 0.002$). Children with lower motor proficiency ($\leq 25^{\text{th}}$ percentile) had a significantly larger mean waist circumference ($M = 13.85\text{cm}$, 95% CI [2.05, 25.66], $p = 0.01$), heavier weight ($M = 22.17\text{kg}$, 95% CI [2.44, 41.91], $p = 0.02$) and higher BMI ($M = 5.10 \text{ kg/m}^2$, 95% CI [0.33, 9.87], $p = 0.03$) than children with higher motor proficiency ($\leq 75^{\text{th}}$ percentile).

Conclusions: Motor proficiency, once corrected for age, is significantly related to a number of health-related measures in children and should therefore be considered a focus for investigation for children with poor health-related fitness (e.g. high BMI and WC percentiles or low cardiorespiratory fitness), as motor incompetence could be an underlying contributing factor to a child's poor physical health.

Key Words: Motor skills, Children, Waist Circumference, Blood Pressure, Fitness, Health.

3.3 SUMMARY STATEMENT

What is already known on the topic?

1. The physical fitness of children and adolescents internationally has been declining over the past 30 years.
2. In order for children to be physically fit, they need to be physically active.
3. To be physically active children require the combined attributes of both health-related fitness (e.g. cardiorespiratory endurance, heart and blood pressure responses to exercise and body composition) and performance-related fitness (e.g. motor proficiency)

What this study adds?

1. Motor proficiency, after controlling for age and gender is negatively associated with health-related measures including resting systolic and diastolic BP, weight, BMI and WC and has a positive relationship with cardiorespiratory fitness (VO_{2peak}).
2. Strength and Running Speed and Agility were the strongest contributors to the relationship between motor proficiency and the health-related measures of WC, BMI and cardiorespiratory fitness (VO_{2peak}).

3.4 INTRODUCTION

The physical fitness of children and adolescents internationally has been declining over the past 30 years with adiposity increasing (Tomkinson, Leger, Olds et al, 2003; Wedderkopp, Froberg, Hansen & Anderson, 2004). In order for children to be physically fit, they need to be physically active (Andersen, Harro, Sardinha et al, 2006) and to do this children require the combined attributes of both health-related fitness (e.g. cardiorespiratory endurance, heart and blood pressure responses to exercise and body composition) and performance-related fitness (e.g. motor proficiency) (Haga, 2008a).

Children and adolescents with lower motor proficiency have a significantly higher Body Mass Index (BMI) compared to those with high motor proficiency (Wrotniak, Epstein, Dorn et al, 2006). Additionally, motor skills have been shown to be significant predictors of BMI, indicating that individuals with low motor competence are more likely to have compromised health-related fitness (Cantell, Crawford & Tish Doyle-Baker, 2008; Haga, 2008b). In addition to BMI, waist circumference (WC) has previously been shown to be a significant predictor for ability to perform fundamental motor skills such as running, jumping, catching, throwing, striking and kicking (Oakley, Booth & Chey, 2004). Furthermore, children with poor motor proficiency are more likely to choose a less active lifestyle in order to avoid the movement difficulties they possess (Petrolini, Lughetti & Bernasconi, 1995). This may create a vicious cycle of further sedentary behaviour, decreased physical activity, and worsening states of fitness, including cardiorespiratory fitness. Higher motor proficiency is associated with increased enjoyment of physical activity (Oakley & Booth, 2000), thus one could reasonably predict that a child with good motor skills would be more likely to be physically active and therefore possess enhanced health-related fitness (i.e. higher cardiorespiratory fitness, with BMI and WC in the 'healthy' categories). However, no studies to date have assessed the relationship between motor proficiency, using an internationally recognised and standardised motor assessment tool, and health-related fitness (including a direct measure of cardiorespiratory fitness, such as VO_2peak) in typically developing Australian children.

This study therefore aimed to: 1) examine the relationship between motor proficiency and health-related fitness in a general school-based cohort of children; 2) determine if the relationship differs for children with lower motor proficiency compared to children with higher motor proficiency and; 3) determine if particular combinations of motor skills have a stronger relationship with individual health-related fitness measures.

3.5 METHODS

Participants

Children aged 5–17 years living in Queensland, Australia were recruited from the general population via advertisement to local schools. Inclusion criteria required children to be attending school and to be medically well at the time of assessment. Children were excluded from the study if they had an underlying medical condition e.g. orthopaedic or neurological conditions that limited their mobility and prevented completion of the standardised motor assessments. Informed consent and parent completed medical history forms were sent with an explanatory statement to the parents of the children volunteering for the study. Children were subsequently offered appointments to complete the research activities either at Bond University or at their school.

Experimental Design

A cross sectional study design was implemented for this study with 77 children (n=F:28; M:49). Each child was seen for a single 2 hour visit to complete the health and motor proficiency measures. After familiarisation with the experimental design and study equipment, resting heart rate (HR) and blood pressure (BP) as well as anthropometric measures of height, weight and waist circumference (WC) were measured for each child before they completed the motor assessment. Twenty-four (31%) (n=F:6; M:18) participants also consented to complete an incremental exercise test to volitional fatigue to determine their peak oxygen uptake (VO_2 peak) as a direct measure of cardiorespiratory fitness. Further participants partaking in VO_2 peak testing was prohibited due to testing being undertaken in the school environment, which was not conducive to the use of specialised equipment required for this assessment. Bond University Human Research Ethics Committee (BUHREC) approved the experimental protocols for the present study which conform to the provisions of the Declaration of Helsinki.

Protocols

Health-related Measures

After 10 minutes of quiet rest, HR and BP were measured in a seated position using a portable self-inflating blood pressure monitor (Omron T9P, Kyoto, Japan). Paediatric and small adult blood pressure cuffs were used depending on mid biceps circumference. Height, weight and WC measurements were taken individually behind a privacy screen, to prevent other children observing the measures. Standing height was measured barefooted at the end of tidal inspiration on a solid surface using a tape measure to the nearest 0.5cm. Weight was measured with light clothing on (e.g. shirt and shorts), using calibrated digital weight scales (HD-366, Tanita Corporation, Tokyo, Japan). Height and weight measurements were used to calculate BMI, including percentiles and Z scores, using CDC growth charts (Centers for Disease Control and Prevention, 2014). WC was measured to the nearest 0.5cm at the height of the umbilicus.

Motor Skill Proficiency

The Bruininks Oseretsky Test of Motor Proficiency (BOT2) is a valid and reliable diagnostic and evaluative tool (Bruininks & Bruininks, 2005)) that was used to assess motor proficiency of all participants. The BOT2 includes a number of subtests: Fine Motor Precision and Fine Motor Integration Total Point Scores (TPS) combine to make up the *Fine Manual Control scale score*; Manual Dexterity and Upper Limb Coordination TPS combine to make up the *Manual Coordination scale score*; Bilateral Coordination and Balance TPS combine to make up the *Body Coordination scale score*; Running Speed and Agility and Strength TPS combine to make up the *Strength and Agility scale score*. The scale scores combine to make up the Standard Scores (SS) which take into account age and gender and are totaled to make up the Total Motor Proficiency SS. All Standard Scores are converted to a percentile rank. Standardised instructions and scoring methods were applied in the assessment process as per the BOT2 assessment manual (Bruininks & Bruininks, 2005), with the exception of the order of testing, which was scheduled around cardiorespiratory fitness testing.

Determination of peak oxygen uptake ($\text{VO}_{2\text{peak}}$)

To determine peak oxygen uptake ($\text{VO}_{2\text{peak}}$), participants performed an incremental exercise test to volitional fatigue on a motor-driven treadmill ('Valiant'; Lode B.V., Groningen, Netherlands). A predetermined preferred walking speed of 4.0-5.0 km/h at 0% grade for 4 min was used to commence the test, before increasing the speed every 60 s until the participant achieved a previously determined ideal running speed (6.0-8.0 km/h). For younger children a 1% increase and for adolescents a 2% increase in treadmill grade was introduced every 60 s until participant's demonstrated volitional fatigue. Cardiac rhythm using a 12-lead ECG (Cardio Perfect, Welch Allyn Inc., Skaneateles Falls, USA) was monitored throughout the test and brachial artery BP was measured and recorded every 3 min. A calibrated open-circuit metabolic measurement system (Ultima CPX, Medical Graphics Corporation, St Paul, USA) was used to measure breath-by-breath values for oxygen uptake (VO_2), carbon dioxide output (VCO_2), and minute expired ventilation. The average of the two highest consecutive 30 s values measured before volitional fatigue were used to determine peak exercise values.

Data Analysis

Means and standard deviations were calculated for age and all health-related and motor performance-related measures for the total study group and four subgroups that were determined according to motor proficiency quartiles (BOT2 Standard Scores sorted into quartiles). Independent *t* tests were used to assess differences in descriptive characteristics and health and performance-related fitness measures between boys and girls. Analysis of variance (1-way ANOVA) was used to determine differences in health-related measures between the four motor proficiency quartile subgroups using Sidaks post-hoc analysis to determine the point of difference if it occurred. Pearson's product moment correlations were computed to assess the relationship between health-related measures and motor proficiency for the total group and individually for the 1st (lowest) and 4th (highest) motor proficiency quartile subgroups. Multiple regression analysis was used to determine the strength of the

relationship between certain models of motor proficiency and health measures when age and gender were factored into the analysis. Statistics were analysed with SPSS for Windows (Version 21.0) with a significance level set at $p < 0.05$.

3.6 RESULTS

Seventy-seven children (F:28, M:49, Mean Age: 11.19 ± 2.74 yr) participated in this study with a mean BMI in the 'healthy-weight' category but ranging from underweight ($< 5^{\text{th}}$ percentile) ($n=3$, 3.9%) to morbidly obese ($> 99^{\text{th}}$ centile) ($n=1$, 1.3%). The majority ($n=59$, 76.6%) were in the healthy weight range with eight (10.4%) overweight and seven (9.1%) obese/morbidly obese. The mean motor proficiency of participants was in the 'average' range with a mean peak oxygen uptake of 44.13 ± 13.03 mL/kg/min. The health-related fitness characteristics of all study participants are provided in Table 5.1, including those in the 1^{st} (lowest) and 4^{th} (highest) motor quartile groups. Significant differences existed between boys and girls in the total group for age ($t = -2.073$, $DF=75$, $p=0.042$), height, weight, HR and systolic BP but not BMI, WC or diastolic BP (see Table 5.1). There was no significant difference between girls and boys for $VO_{2\text{peak}}$ ($t = -0.622$, $DF=22$, $p=0.54$).

A one-way ANOVA with Sidaks post-hoc analysis revealed no significant differences between participants in the 1^{st} (lowest) motor quartile group and the 4^{th} (highest) motor quartile group for resting HR, BP or height (Table 5.1). Additionally there were no significant differences between these subgroups for age ($p=0.33$) or $VO_{2\text{peak}}$ ($p=0.21$). However, participants in the 1^{st} motor quartile group had significantly larger WC, heavier weight and higher BMI than participants in the 4^{th} motor quartile group. Figure 5.1 outlines the variation in mean WC and BMI for participants in each of the motor quartile groups. Motor performance-related fitness characteristics of study participants are reported in Table 5.2. No significant differences existed between boys and girls for any of the BOT2 Total Point Scores.

Table 5.1 Health-related fitness characteristics of study participants in total group and 1st and 4th motor quartile groups.

Variable	Total Group (n=77)	Difference between Males and Females	1 st Motor Quartile Group (n=13)	4 th Motor Quartile Group (n=34)	Difference between 1 st & 4 th Motor Quartile Groups
	Mean ± SD	p-value	Mean ± SD	Mean ± SD	p-value
Height (cm)	147.01±18.12	0.048*	150.77±25.37	140.16±11.61	0.33
Weight (kg)	42.66±23.55	0.035*	56.37±45.17	34.20±9.10	0.02*
BMI (kg/m ²)	18.72±5.62	0.091	22.25±11.24	17.14±2.59	0.03*
BMI (percentile)	50.81±31.146	0.379	60.69±33.03	44.79±32.35	0.54
Z-BMI	0.041±1.11	0.388	0.44±1.39	-0.18±1.14	0.44
WC (cm)	67.33±14.09	0.052	76.19±24.78	62.34±7.31	0.01*
WC (% range)	50-75th	-	75-90th	25-50th	-
Resting HR (beats/min)	80.75±13.41	<0.001*	76.19±24.78	84.00±13.29	0.26
Resting Systolic BP (mmHg)	117.07±15.62	0.028*	121.07±21.29	112.44±12.37	0.43
Resting Diastolic BP (mmHg)	69.68±11.51	0.774	73.54±13.94	65.65±10.13	0.18

Data presented as mean ± SD. WC - Waist Circumference, HR – Heart Rate, BMI – Body Mass Index, BP – Blood Pressure. *Sidaks post hoc test is significant at the 0.05 level.

1st Motor Quartile - BOT2 Quartile Standard Score (0 to ≤ 25%)

4th Motor Quartile - BOT2 Quartile Standard Score (>75% to ≤ 100%)

Table 5.2 Motor performance-related fitness characteristics of study participants.

BOT2 Variable (No.)	Total Point Score	Standard Score	Percentile Rank	Difference between Males and Females
(n=77)		Mean \pm SD		p-value
Fine Motor Precision	37.77 \pm 3.99	N/A	N/A	.529
Fine Motor Integration	35.79 \pm 4.60	N/A	N/A	.361
Fine Manual Control	N/A	49.71 \pm 9.06	48.16 \pm 27.67	-
Manual Dexterity	31.42 \pm 5.21	N/A	N/A	.233
Upper-Limb Coordination	34.88 \pm 5.42	N/A	N/A	.469
Manual Coordination	N/A	54.17 \pm 8.63	62.25 \pm 26.59	-
Bilateral Coordination	21.87 \pm 3.42	N/A	N/A	.053
Balance	32.56 \pm 3.71	N/A	N/A	.399
Body Coordination	N/A	50.68 \pm 9.65	51.46 \pm 29.54	-
Running Speed and Agility	37.77 \pm 6.00	N/A	N/A	.543
Strength	29.90 \pm 5.47	N/A	N/A	.305
Strength and Agility	N/A	58.04 \pm 8.36	73.95 \pm 23.06	-
Total Motor Proficiency		54.36 \pm 10.00	61.68 \pm 29.06	-

Data presented as mean \pm SD.

Significance level set at $p < 0.05$.

Table 5.3 presents Pearson's product moment correlations between motor proficiency (BOT2 Standard Scores) and health-related fitness measures for the total group and the 1st motor quartile subgroup. For children in the 4th motor quartile group, a small negative relationship was found between WC and Total Motor Proficiency SS ($r = -0.341$, $p=0.048$). No other significant relationships between health-related fitness measures and motor proficiency (BOT2 Standard Scores) were observed for the children in this group. Pearson's correlations were also undertaken to assess the relationship between the BOT2 Standard Scores and VO_2 peak (mL/kg/min) for those

who completed the incremental exercise test ($n=24$, Mean BMI Percentile= 53.86 ± 33.08 , Mean BMI Z score= 0.19 ± 1.37 , Mean Total Motor Proficiency Rank= 53.88 ± 32.53). Significant positive correlations existed between Total Motor Proficiency SS and VO_{2peak} (mL/kg/min) ($r=0.418$, $p=0.042$) as well as the Strength and Agility SS and VO_{2peak} (mL/kg/min) ($r=0.630$, $p=0.001$). This relationship strengthened considerably when examined for children in the 1st Motor Quartile Group ($n=6$), ($r=0.948$, $p=0.004$). No significant difference was found for age ($t=-3.088$, $DF=75$, $p=0.375$), Total Motor Proficiency ($t=1.700$, $DF=75$, $p=0.195$) or BMI percentile ($t=-0.659$, $DF=75$, $p=0.659$) for children who completed VO_{2peak} testing compared to those who did not.

Multiple regression analysis was used to examine the contribution of age and gender to the relationship between motor proficiency (BOT2 Scores) and health-related fitness and these results are provided in Table 5.4. Although a model of combined BOT2 TPS + Age + Gender, was found to have the strongest relationship with the independent measures of WC, BMI and VO_{2peak} , the influence of gender to these relationships was not significant (WC: $p=0.148$, BMI: $p=0.079$, VO_{2peak} : $p=0.291$) and gender could therefore be removed from the model with negligible effect (see Table 5.4). Notably, the relationship between the health-related fitness measures and a combined model of Strength TPS and Running Speed and Agility TPS + Age, was almost as strong as the model that included all motor subtests (combined BOT2 TPS).

Table 5.3 Pearson's correlations between motor proficiencies and health-related fitness measures.

BOT2 Standard Score (SS)	RSBP (mmHg)	RDBP (mmHg)	Weight (kg)	BMI (kg/m ²)	WC (cm)
	r	r	r	r	r
Total Group (n=77)					
Fine Manual Control SS	-.321** (.004)	-.279* (.014)	-.378** (.001)	-.277* (.015)	-.383** (.001)
Manual Coordination SS	-.174 (.130)	-.152 (.186)	-.331** (.003)	-.303** (.007)	-.344** (.002)
Body Coordination SS	-.141 (.221)	-.087 (.454)	-.144 (.213)	-.134 (.245)	-.146 (.204)
Strength and Agility SS	-.274* (.016)	-.156 (.174)	-.460** ($<.001$)	-.480** ($<.001$)	-.537** ($<.001$)
Total Motor SS	-.288* (.011)	-.232* (.042)	-.392** ($<.001$)	-.356** (.001)	-.431** ($<.001$)
1st Motor Quartile Group (0% to \leq 25th) (n = 13)					
Fine Manual Control SS	-.493 (.087)	-.447 (.126)	-.216 (.478)	-.073 (.812)	-.204 (.503)
Manual Coordination SS	-.091 (.768)	-.122 (.690)	-.408 (.167)	-.396 (.180)	-.436 (.136)
Body Coordination SS	-.310 (.303)	.016 (.959)	-.036 (.908)	-.036 (.908)	.540 (.057)
Strength and Agility SS	-.488 (.090)	.037 (.904)	-.701** (.008)	-.723** (.005)	-.745** (.003)
Total Motor SS	-.721** (.005)	-.141 (.646)	-.739** (.004)	-.631* (.021)	-.769** (.002)

Pearson's Correlation Coefficients - significance level shown in brackets.

**Pearson Correlation is significant at the 0.01 level (2-tailed).

*Pearson Correlation is significant at the 0.05 level (2-tailed).

RSBP – Resting Systolic Blood Pressure, RDBP – Resting Diastolic Blood Pressure, BMI – Body Mass Index, WC – Waist Circumference.

Table 5.4 Multiple regression coefficients between motor proficiency models and health-related fitness measures.

Regression Models	WC (cm) (n=77)		BMI (kg/m ²) (n=77)		VO ₂ peak (mL/kg/min) (n=24)	
	r ²	SE of Estimate (%)	r ²	SE of Estimate (%)	r ²	SE of Estimate (%)
Gender + Age + Combined BOT2 TPS	0.725** (<0.001)	11.77	0.638** (<0.001)	19.39	0.803** (0.003)	15.13
Age + Combined BOT2 TPS	0.72** (<0.001)	11.86	0.62** (<0.001)	19.60	0.784** (0.002)	15.24
Gender + Age + Strength TPS + RS&A TPS	0.645** (<0.001)	12.80	0.535** (<0.001)	21.05	0.725** (<0.001)	14.74
Age + Strength TPS + RS&A TPS	0.643** (<0.001)	12.76	0.531** (<0.001)	20.99	0.653** (<0.001)	16.02

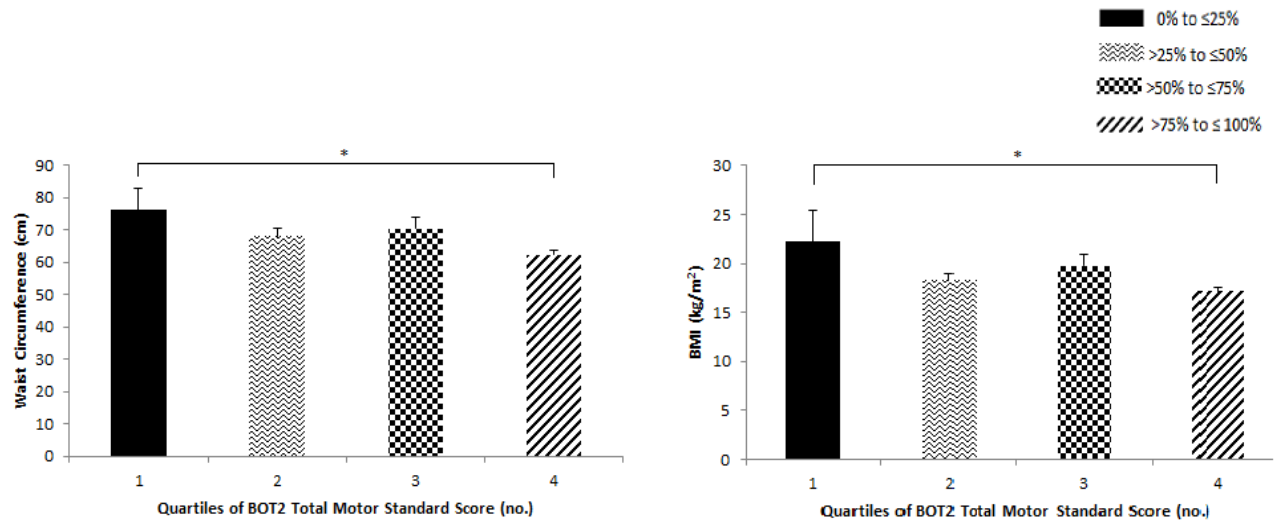
Regression Coefficients - significance level for each value is shown in brackets.

**Regression Coefficient is significant at the 0.01 level

*Regression Coefficient is significant at the 0.05 level

BMI – Body Mass Index, WC – Waist Circumference, TPS – Total Point Score, Combined BOT2 TPS = Fine Motor Precision, Fine Motor Integration, Manual Dexterity, Upper-limb Coordination, Bilateral Coordination, Balance, Running Speed and Agility, Strength.

Figure 5.1 Waist Circumference and BMI for BOT2 Total Motor Proficiency quartile groups.



- 1st Motor Quartile - BOT2 Quartile Standard Score (0 to ≤ 25%)
- 2nd Motor Quartile - BOT2 Quartile Standard Score (>25% to ≤ 50%)
- 3rd Motor Quartile - BOT2 Quartile Standard Score (>50% to ≤ 75%)
- 4th Motor Quartile - BOT2 Quartile Standard Score (>75% to ≤ 100%)

*Sidaks post hoc test is significant at the 0.05 level.

3.7 DISCUSSION

The present study aimed to determine if a relationship existed between motor proficiency and measures of health-related fitness in children and if so, did the relationship differ for children with lower motor proficiency compared to those with higher motor proficiency. The final of our study aims was to determine if particular combinations of motor skills had a stronger relationship with individual health-related fitness measures.

The results of this study indicate that motor proficiency, after controlling for age and gender is negatively associated with health-related measures including resting systolic and diastolic BP, weight, BMI and WC and has a positive relationship with cardiorespiratory fitness (VO_{2peak}). These results address the first of the study aims. When the relationships were examined for children with a motor proficiency equal to or below the 25th percentile, the relationships strengthened considerably for all of these health-related measures, with the exception of resting diastolic BP, addressing the second of the study aims and suggesting that children with reduced motor proficiency are more likely to have poor health-related fitness.

By using a multiple regression analysis we were able to demonstrate that the motor subtests of Strength and Running Speed and Agility were the strongest contributors to the relationship between motor proficiency and the health-related measures of WC, BMI and cardiorespiratory fitness (VO_{2peak}) and these results address the third of the study aims.

The findings of this study are unique, in that a wide range of fine and gross motor skills were investigated, whereas previous research investigating the relationship between fitness and motor proficiency (Haga, 2008a; Haga, 2009) using the Movement Assessment Battery for Children, was only able to establish relationships between the motor subcategories of Manual Dexterity, Ball Skills and Balance. Furthermore, the direct measurement of cardiorespiratory fitness (VO_{2peak}) of a representative subgroup of children in this study, and the subsequent investigation of its relationship with motor proficiency, in a healthy school-based general population cohort, provides a unique exploration of the relationship between children's motor proficiency with health and fitness that has not previously been reported for Australian children.

Considering the high prevalence of childhood obesity, the findings of this study are particularly relevant as strength and running speed and agility are fundamental to day to day activities in the playground and during sport and without proficiency in these

areas, children are likely to be less active and more sedentary as evidenced in prior research (Wrotniak et al, 2006). The overall findings of the present study are supported by previous research (Haga, 2008a) that examined physical fitness in 9 and 10-year-old children, where the authors concluded that children with impaired motor skills displayed reduced physical fitness based on field testing, and subsequently hypothesised that the relatively poor performance-related fitness of children with movement difficulties, was due to lower levels of physical activity, indicating a spiralling 'chicken and egg' effect.

5.8 LIMITATIONS

The present study had some potential limitations that should be considered in any future research in this area. Firstly, the study had more boys than girls and this may have influenced the overall results of the study, considering that there were significant differences between girls and boys for some measures. Secondly, the study population was a relatively small sample size from a defined geographical region of Australia.

5.9 CONCLUSIONS

Overall, findings from this study suggest that motor proficiency, particularly strength and running speed and agility, once corrected for age, can predict health-related status for children. Motor proficiency and specifically strength and running speed and agility, should therefore be considered as a focus of investigation for children with poor health-related fitness, as motor incompetence could be an underlying contributing factor to a child's poor health. Further research is needed to investigate the generalisability of these findings to primary versus high school-aged children and to children from geographical regions outside of the study population. Longitudinal research is required to investigate if motor skills in early childhood can predict health status in later childhood or early adulthood. It is also required to investigate if

targeted intervention based on motor skill development in the primary school years can halt the progression to poor health and chronic disease.

5.10 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 6.

MODIFIED SHUTTLE TEST-PAEDS:

A VALID CARDIORESPIRATORY FITNESS MEASURE FOR CHILDREN

6.1 PRELUDE

This chapter contributed to Stage 2 of the screening tool development in this doctoral research program. Specifically it was the first step in validating the newly designed measures for inclusion in the KidFit Screening Tool. The Modified Shuttle Test - Paeds (MSTP) was designed as a cardiorespiratory fitness measure for children that would better engage young children, take less time to complete than other previously validated field measures, have no 'drop out' nature and be inexpensive to administer. The drop out nature in particular for measures such as the 20m MSRT / BEEP Test, have led to concerns about fitness testing in the Queensland Primary Education sector for fear of stigmatisation of children who drop out early in the testing process. The MSTP was developed with these concerns in mind, in addition to being mindful of developing a cardiorespiratory fitness measure that was goal oriented and would capture and maintain the interest of young children for the duration of the test. In order to have the expertise required to supervise and assist with undertaking the peak oxygen consumption tests (as the gold standard reference for the MSTP) with each of the children in this study, Dr Michael Simmonds (Accredited Exercise Physiologist) was invited to assist with the study design, the collection of data and proofing of the manuscript in preparation for submission to a journal.

6.2 ABSTRACT

Objectives: This study aimed to: 1) Test the concurrent and predictive validity of the Modified Shuttle Test-Paeds (MSTP) as a newly designed measure of cardiorespiratory fitness in children that does not require 'drop-out' for completion, against the gold standard reference: peak oxygen uptake ($\text{VO}_{2\text{peak}}$) and; 2) Contrast the strength of the relationship between the MSTP and $\text{VO}_{2\text{peak}}$, with that of the commonly used 20m-Multi-Stage-Running-Test (20m-MSRT).

Methods: A concurrent validation study design, utilising a convenience sample of 25 school-aged children (age: 6-16yr; male/female: 19/5; BMI: $21 \pm 9 \text{ kg/m}^2$) was employed. Physical measures included: Bruininks-Oseretsky-Test-of-Motor-Proficiency-2nd Edition (BOT2), $\text{VO}_{2\text{peak}}$, 20m-MSRT and MSTP, body composition and basic anthropometry.

Results: The mean cardiorespiratory fitness of participants was: $\text{VO}_{2\text{peak}}$: 43.8 ± 11.2 (mL/kg/min); 20m-MSRT: 5.48 ± 2.96 (level); MSTP: 22.10 ± 3.05 (no.). A significant and strong correlation existed between $\text{VO}_{2\text{peak}}$ and MSTP ($r^2=0.749$, $p<0.001$). The relationship between $\text{VO}_{2\text{peak}}$ and 20m MSRT was significant and moderately strong ($r^2=0.486$, $p<0.001$).

Conclusions: The MSTP is a valid measure of cardiorespiratory fitness with a high predictive validity for estimating $\text{VO}_{2\text{peak}}$ in children, using a simple clinically applicable equation. The MSTP may be considered an alternative measure for predicting $\text{VO}_{2\text{peak}}$, especially in environments where there are sensitivities to measuring cardiorespiratory fitness in children with diverse fitness abilities (e.g. school environments).

Key words: Cardiovascular, field tests, health, obesity, paediatric.

6.3 INTRODUCTION

Over the last 30 years, population-wide surveys have consistently indicated increased adiposity as well as decreased cardiorespiratory fitness in paediatric populations, with approximately 0.5% and 1% per year reductions in performance on field-based cardiorespiratory fitness tests for children and adolescents respectively (Tomkinson, Leger, Olds et al, 2003). These longitudinal trends indicate declining functional capacity for children during weight-bearing activities (Wedderkopp, Froberg, Hansen et al, 2004). Difficulty performing weight-bearing activities will likely limit involvement in recreational physical activity such as lunch-time play, and/or organised sport, further compounding the decreased cardiorespiratory fitness of these children. This spiralling “chicken and egg” effect could consequently impact learning and cognitive performance (Davis, Tomporowski, McDowell et al, 2011; Hill, Williams, Aucott et al, 2010) and lead to chronic disease in adulthood (Magerey, Daniels, Boulton et al, 2003). With accumulating evidence that exercise capacity decreases all-cause mortality (Lee & Skerrett, 2001) independent of adiposity (McAuley, Kokkinos, Oliveira, 2010), there are clear benefits to be gained through the development of cardiorespiratory fitness measures that are specifically and sensitively designed for use with paediatric populations. Such tools could assist with detecting children who would benefit from early intervention to improve cardiorespiratory fitness and prevent subsequent health and educational impairments.

Peak oxygen uptake (VO_{2peak}), the highest VO_2 elicited during a given exercise bout to exhaustion, is widely accepted as a valid marker of cardiorespiratory fitness in children (Washington, Bricker, Alpert et al, 1994). However, laboratory testing to determine VO_{2peak} is not commonly used with children in health professional rooms or field environments as it requires expensive equipment and specialist skills to collect and analyse the data. A measure of cardiorespiratory fitness which is more frequently used in school or community environments is the 20-Metre Multistage-shuttle-run-test (20mMSRT) (Leger & Lambert, 1982; Leger, Mercier, Gadoury et al, 1988). This measure can take up to 20 minutes to complete, depending on fitness and its

popularity can be attributed to its practical use for simultaneous measurement of large groups. However, when used in large groups, the level of achievement becomes obvious to peers, as each individual 'drops out' at the point of exhaustion, exposing children who are less fit to potential stigmatisation by peers. As such, a cardiorespiratory fitness measure which is inexpensive, shorter in duration, does not require specialist clinical skills, does not have a "drop out" nature, requires less space and is therefore more suited to screening the fitness of children in schools or health professional environments is warranted.

The Modified-Shuttle-Test-Paeds (MSTP) has been specifically and sensitively designed to address the limitations of current cardiorespiratory testing methods. It involves a task-oriented approach while the child runs a 10-metre shuttle, picking up a hand-held bean bag, turning around and returning to the start point to place the bean bag in a tray. This is repeated as many times as possible in 3 minutes. The test can be performed individually or in class groups, whereby all children are instructed to perform at maximal effort for the full 3 minutes. This study therefore aims to 1) test the concurrent and predictive validity of the MSTP as a measure of cardiorespiratory fitness in children, against the gold standard reference: $\text{VO}_{2\text{peak}}$ and; 2) Contrast the strength of the relationship between the MSTP and $\text{VO}_{2\text{peak}}$, with that of the 20m MSRT.

6.4 METHODS

Participants

Twenty-five children (age: 6-16 yr; male/female: 19/5; BMI: $21 \pm 9 \text{ kg/m}^2$) volunteered to participate in the present study after advertisement to local schools and through community flyers. Eligible participants were aged 5 to 17 years inclusive and attended school. Children diagnosed with mobility-limiting orthopaedic conditions, cardiac, non-reversible pulmonary or neurological conditions were excluded from participation. Informed parent/legal guardian consent and participant assent, in addition to a parent

completed medical history form were obtained for the children wishing to participate in the study.

Experimental Design

Participants were briefed on the experimental procedures and familiarised with the equipment prior to their test day which for all children occurred in the summer of 2013. Basic anthropometry, clinical evaluations, motor proficiency, and various indices of cardiorespiratory fitness were measured. All children were encouraged to have a light breakfast 2 hours before their appointment. Heart rate and blood pressure were measured in a seated position after 10 minutes of quiet rest upon arriving at the laboratory. Height, weight and bioimpedance measures were subsequently measured, before each participant completed the first cardiorespiratory fitness test; the 20m MSRT. Following the completion of the 20m MSRT, a one hour washout period was implemented to allow the participant to recover to a resting state. Apart from the 20m MSRT always being scheduled as the first of the cardiorespiratory fitness measures (due to room booking restrictions), all other measurements (including motor proficiency testing) were randomly assigned to each participant with special consideration of implementing washout periods of no less than 1 hour between strenuous assessments. Five participants required a physician to be present during incremental exercise testing due to being considered 'higher risk' for exercise-induced complications, which included those who were obese (BMI >95th percentile) or presented with asthma. Bond University Human Research Ethics Committee reviewed and approved the experimental protocol for the present study (RO1601).

Procedures

Anthropometric and Body Composition Measures

Standing height was measured barefooted at the top of a tidal inspiration on a solid surface using a tape measure to the nearest 0.5 cm. Body mass was measured while participants wore light clothing (e.g., shirt and shorts) using a commercially available body composition analyser (MC-980MA, Tanita Corporation, Tokyo, Japan).

Participants were blinded to their body composition through the implementation of a barrier-screen over the instruments digital display.

Motor Skill Proficiency

The BOT2 (Bruininks & Bruininks, 2005) is a valid and reliable diagnostic and evaluative tool for children aged 4.5 – 21 years, that was used to determine total motor proficiency percentile ranks to ascertain if the study cohort was representative of the Australian population of children. It also acted as a pre-test for any children who continued into the intervention, a second stage of this study (not reported in this paper). The study protocol required this test to be broken up into fine and gross motor subtests as separate stations for testing. Exceptions to the standardised instructions included the order of testing, which was scheduled around the cardiorespiratory fitness measures and washout periods.

20m MSRT Protocol

The 20m MSRT was completed by all participants. This valid and reliable field test (Leger et al, 1988) is a commonly utilised assessment of cardiorespiratory fitness. The protocol for this measure included the participants being instructed to repeatedly run between two markers placed 20m apart until volitional fatigue. The 20m MSRT progressively increases intensity, with the pace of the test indicated by audible tones on a music player, commencing at a speed of 8.0 km/hr which is increased by 0.5 km/hr each stage after the first minute. This test was conducted in an indoor environment and was terminated when a participant failed to reach the 20m marker on two consecutive shuttle runs (laps). The outcome measure was the total number of laps completed for each individual, which was subsequently converted to the level completed before the test was terminated.

Modified Shuttle Test Paeds (MSTP) Protocol

The MSTP was completed by all participants. Participants were instructed to run a straight 10 metre shuttle, pick up 1 hand-held bean bag from a tray (10cm high x 40cm

width, 30cm length) on the ground, turn around and return to the start point to place the bean bag into an identical size tray at the start line and repeat this task as many times as possible in 3 minutes. Children were encouraged strongly throughout the test with verbal encouragement, particularly towards the end to ensure maximal effort was achieved. One (1) point was scored for every bean bag returned to the tray at the 3 minute completion time. A further half (1/2) point was added to the score if the test finished after the child had picked up a bean bag but had not yet returned it to the tray.

Determination of peak oxygen uptake and ventilatory thresholds

Participants performed an incremental exercise test to volitional fatigue on a motor driven treadmill ('Valiant'; Lode B.V., Groningen, Netherlands) for the determination of peak oxygen uptake ($\text{VO}_{2\text{peak}}$), time to exhaustion and ventilatory thresholds. Participant's commenced exercise at a predetermined preferred walking speed of 4.0-5.0 km/hr at 0% grade for 4 min, before the speed was increased every 60 s until the participant achieved their previously determined preferred running speed (6.0-8.0 km/hr). Treadmill grade was then increased by 1% (younger participants) or 2% (adolescents) every 60 s, with strong verbal encouragement at each level, until volitional fatigue or signs and symptoms precluded further exercise. During the incremental exercise test, cardiac rhythm was monitored using a 12-lead ECG (Cardio Perfect, Welch Allyn Inc., Skaneateles Falls, USA) and brachial artery blood pressure was measured and recorded every 3 min. Oxygen uptake, carbon dioxide output (VCO_2), and minute expired ventilation were measured breath-by-breath using a calibrated open-circuit metabolic measurement system (Ultima CPX, Medical Graphics Corporation, St Paul, USA). Peak exercise values were determined as the average of the two highest consecutive 30 s values measured before volitional fatigue. The ventilatory thresholds were determined according to methods previously described (Beaver, Wasserman & Whipp, 1986; Wasserman, Hansen, Sue et al, 1994).

Statistical analyses

Means, standard deviations and bivariate correlations were calculated for all physiological, anthropometrical and aerobic fitness measures. After assumptions of normality and linearity were tested, independent t tests were used to assess cross-sectional differences in measured variables between groups for gender. Pearson's product moment correlations were performed to assess the relationship between participants' physiological and anthropometrical characteristics and measures of aerobic fitness. Simple linear regression analysis was used to determine the degree by which the MSTP Total score could predict $\text{VO}_{2\text{peak}}$ (mL/kg/min). Multiple regression analysis was then used to determine if the predictive validity of the MSTP for estimating $\text{VO}_{2\text{peak}}$ could be further strengthened by the addition of other variables (e.g. age, gender, weight and height) and to establish a prediction equation of $\text{VO}_{2\text{peak}}$ from the MSTP. Statistics were analysed with SPSS for Windows (Version 21.0). Significance level was set at $p < 0.05$. Power analyses were performed using an effect size calculator (Ellis, 2014) and G-power Software, Version 3.1.7 (Faul, Erdfelder, Buchner et al, 2009). This was performed post-hoc as no data previously existed for the MSTP. A power analysis for correlation statistics revealed that with a sample of 24 participants, and a 2-tailed α value of 0.05 and an expected effect size of at least $r = 0.6$, a statistical power of 94% can be achieved.

6.5 RESULTS

Twenty-five children ranging from underweight to morbidly obese participated in this study. One child did not complete $\text{VO}_{2\text{peak}}$ testing on the treadmill due to the identification of a cardiac arrhythmia that precluded further exercise testing. Six (24%) children in this study were classified as overweight or obese using both the Centers for Disease Control and Prevention (CDC) BMI percentile ranges ($\geq 85^{\text{th}}$ percentile) (Centers for Disease Control and Prevention, 2014) and the International Obesity Task Force (IOTF) reference ranges for children (Cole, Bellizzi, Flegal et al, 2000). This figure is consistent with the Australian population of approximately 1 in 4 children being overweight or obese (Department of Health, Australian Government, 2008). The mean

BMI percentile for boys was 51.58 ± 36.27 and for girls was 52.67 ± 28.19 , placing the means for both genders in the 'healthy weight' range. The mean Total Motor Proficiency Percentile Rank for children in the study was 55.24 ± 33.13 , indicating that overall the children in this study had 'average' motor skill ability with a wide range of motor proficiency from 'low' to 'very high'.

Table 6.1. Physiological and anthropometric characteristics of study participants and correlations with cardiorespiratory fitness measures

Characteristics	Mean \pm SD	Pearson correlations with aerobic fitness measures.		
		VO2Peak (mL/kg/min) (n=24)	MSTP (no.) (n=25)	20mMSRT (no.) (n=25)
Age (yr)	12.58 ± 2.68	-.111 (0.605)	.042 (0.840)	.394 (0.051)
Height (cm)	158.56 ± 0.24	-.252 (0.234)	-.098 (0.643)	.282 (0.172)
Body Mass (kg)	56.15 ± 34.30	-.662** (<0.001)	-.653** (<0.001)	-.233 (0.261)
BMI (kg / m ²)	20.96 ± 8.75	-.728** (<0.001)	-.766** (<0.001)	-.382 (0.059)
BMI (Percentile)	51.84 ± 33.94	-.590** (0.002)	-.590** (0.002)	-.290 (0.159)

Pearson's Correlation Coefficients - significance level for is shown in brackets.

**Pearson Correlation is significant at the 0.01 level (2-tailed).

*Pearson Correlation is significant at the 0.05 level (2-tailed).

Table 6.1 outlines the physiological and anthropometric characteristics of study participants and correlations of these measures to cardiorespiratory fitness results. For the present study, the MSTP, 20m MSRT and VO₂peak expressed in mL/kg/min, had no significant relationships with age or height. Body mass but more so BMI (kg / m²) were shown to have moderate to high significant negative correlations with VO₂ peak (mL/kg/min) and MSTP but these relationships were not significant with the 20m MSRT.

The cardiorespiratory fitness characteristics of the study participants are summarised in Table 6.2. Statistical analysis using *t* tests for investigating equality of means demonstrated no significant differences between boys and girls in mean MSTP scores (M:22.21±3.41, F:21.75±1.60, *t* = -0.316, DF=23, *p*=0.755), 20m MSRT (M: 6.11±3.07, F: 3.5±1.38, *t* = -1.993, DF=23, *p*=0.058) or the directly measured VO₂peak (M: 44.65±12.78, F:41.32±3.55, *t* = -0.622, DF=22, *p*=0.540).

Table 6.2 Cardiorespiratory fitness characteristics of study participants during incremental exercise testing and field tests.

Variable	Mean ± SD (n=24)
VO ₂ peak (mL/kg/min)	43.8 ± 11.2
VT1 (mL/kg/min)	26.2 ± 7.8
VT2 (mL/kg/min)	37.1 ± 9.2
HRpeak (beats/min)	190 ± 12
RERpeak	1.12 ± 0.11
MSTP Total Score (No.)	22.10 ± 3.05
20m MSRT Level (No.)	5.48 ± 2.96
Predicted VO ₂ max (mL/kg/min)	45.93 ± 7.71

Data presented as mean ± SD. VO₂peak: peak oxygen uptake, VT: ventilatory threshold, HRpeak: peak exercise heart rate, RERpeak: peak respiratory exchange ratio, MSTP: Modified Shuttle Test – Paeds, 20m MSRT: 20m Multistage Running Test, Predicted VO₂max from 20m MSRT using Leger’s predictive equation (Leger et al, 1988).

In order to establish the validity of the MSTP and to determine the strength of the relationship of the MSTP to VO₂peak as well as the 20m MSRT to VO₂peak, Pearson’s product moment correlations were undertaken (Table 6.3). The results demonstrated that the MSTP total score was significantly and strongly correlated with the gold

standard measure of cardiorespiratory fitness: $\text{VO}_{2\text{peak}}$. In order to determine the predictive validity of the MSTP for approximating $\text{VO}_{2\text{peak}}$ (mL/kg/min), simple regression analyses were also undertaken (Table 6.3).

Table 6.3 Pearson's correlations (r) and regression coefficients (r^2) between $\text{VO}_{2\text{peak}}$ (mL/kg/min) and alternative field tests for cardiorespiratory fitness

Variable	All Study Participants (n=24)	
	r	r^2
MSTP (No.)	.866** (<0.001)	.749 ^{β} (<0.001)
20m MSRT (No.)	.697** (<0.001)	.486 ^{β} (<0.001)
Predicted $\text{VO}_{2\text{max}}$ from 20m MSRT	.780** (<0.001)	.608 ^{β} (<0.001)

For Pearson's Correlations and Regression Coefficients, the level of significance for each value is shown in brackets. MSTP: Modified Shuttle Test–Paeds; MSRT: Multistage Running Test. Predicted $\text{VO}_{2\text{max}}$ from 20m MSRT using the Leger et al (1988) equation.

**Pearson Correlation is significant at the 0.01 level (2-tailed).

*Pearson Correlation is significant at the 0.05 level (2-tailed).

^{β} Regression Coefficient is significant at the 0.05 level.

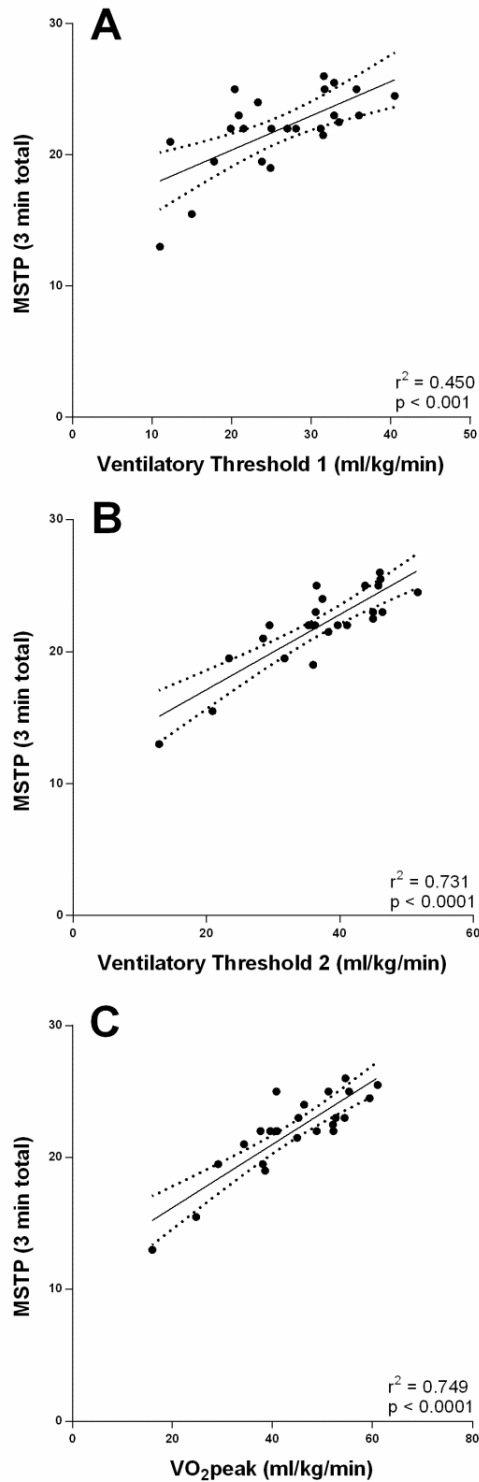
The MSTP was found to have a high predictive validity for estimating $\text{VO}_{2\text{peak}}$, accounting for 75% of the variance in $\text{VO}_{2\text{peak}}$ for children in this study, with a standard error of the estimate of 5.64 mL/kg/min or 12.78%. The 20m MSRT accounted for 49% of the variance in $\text{VO}_{2\text{peak}}$, with a standard error of the estimate of 8.08 mL/kg/min or 18.31%. In order to determine if the addition of other variables could further strengthen the predictive validity of the MSTP in this study, a multiple

regression analysis was undertaken and showed that in the presence of MSTP; gender, age, weight and height were not significant predictors of VO_2peak . VO_2peak in children can therefore be validly predicted from the MSTP using the following equation:

$$1. [\text{VO}_2\text{peak (mL/kg/min)} = (-24.5 + (3.122 \times \text{MSTP Total Score}))].$$

As ventilatory threshold 1 (VT1) and 2 (VT2), along with VO_2peak are all important parameters of cardiorespiratory fitness, a simple regression analysis was performed investigating their relationship with the MSTP. Figure 6.1 outlines the strength of the relationship between the MSTP and these important parameters of cardiorespiratory fitness: VO_2 peak (mL/kg/min), VT1 and VT2, which were all strongly and positively related to the MSTP score.

Figure 6.1. Relationship of the MSTP to important parameters of cardiorespiratory fitness (VT1, VT2, VO₂peak). Dotted line indicates 95% CIs.



6.6 DISCUSSION

The salient findings of the present study were that a field-based assessment of cardiorespiratory fitness (i.e., MSTP), that was sensitively designed for a paediatric population, was a strong predictor of VO_2peak , VT1 , and VT2 : three measures of cardiorespiratory performance obtained during criterion graded exercise testing. This finding is important for clinical practice, given that the MSTP: i) can be performed in an environment requiring less space (i.e., 10m laps) than other field based shuttle tests; ii) requires no specialised or expensive equipment; iii) promotes individualised and discrete assessment of cardiorespiratory fitness, given that the test is conducted over a defined period of time (3 min) and the outcome measure (no. of beanbags in the trays) is not directly visible to other children. The importance of these factors cannot be overstated, given the rising prevalence of childhood overweight/obesity with reduced cardiorespiratory fitness and the associated challenges to positive self-worth that may not be promoted in classic “drop-out” or comparative assessment methods (e.g., 20m MSRT / BEEP test).

It is known that VO_2peak is a strong determinant of future all-cause mortality and also incidence of morbidity associated with increasingly prevalent lifestyle disorders (e.g., metabolic syndrome) (Twisk, Kemper & van Mechelen, 2002); consequently the clinical relevance of determining cardiorespiratory fitness is well established. There are many limitations to performing routine determination of VO_2peak , including the burden of necessary expertise and specialised equipment, resulting in a reduced accessibility to criterion forms of assessment. The results of the present study suggest that the MSTP is a suitable alternative to the criterion graded exercise test for determining cardiorespiratory fitness, which directly addresses our first study aim. Irrespective of adiposity, age, or gender, the number of beanbags transported over three minutes during the MSTP was significantly and positively related to the participants VO_2peak determined during treadmill testing, suggesting that the 3 minutes of this maximal intensity exercise was enough to drive the levels of VO_2 close to peak levels. Moreover, the relative strength, linearity, and narrow confidence intervals of the relationship

between the MSTP score and VO_2peak (see Figure 6.1) confirm that this method of assessing cardiorespiratory fitness does not present systematic bias and is suitable across the range of aerobic capacities typical for paediatric and adolescent cohorts. These results were comparable to previous studies with children. For example, earlier studies developed VO_2peak prediction equations from the 20m MSRT that accounted for 68 - 88% of the variance of VO_2max when different combinations of sex, age and anthropometric data were included (Leger et al, 1988; Barnett, Chan & Bruce, 1993; McVeigh, Payne & Scott, 1995; Pitetti, Fernhall & Figoni, 2002; Matsuzaka, Takahashi, Yamazoe et al, 2004).

A second aim of this study was to contrast the strength of the relationship between the MSTP and VO_2peak with that of another commonly utilised field test: 20m MSRT. In the present study, the MSTP as a raw measure was found to have a stronger relationship with VO_2peak than the 20m MSRT, even when applying Leger et al's predictive equation (Leger et al, 1988) to estimate VO_2max from the 20m MSRT by factoring in gender (see Table 6.3). While previous studies have demonstrated that other field-based assessment methods (e.g., 20m MSRT; 2.4 km run etc.) can be effective for estimating cardiorespiratory fitness, these assessments tend to rely upon outcome measures that may negatively impact upon well-being and self-worth among those participants who perform poorly. An obese child, for example, who is also a slow runner may "drop out" of the shuttle-based tests earlier than classmates, or take a much longer time to complete a fixed distance assessment, which would ultimately and directly lead to peer recognition of their poor performance. The MSTP, on the other hand, enables an individual's cardiorespiratory fitness to be assessed in a more discrete manner, with all children completing the test in 3 minutes, yet provides an outcome measure that is more strongly associated with the criterion measured VO_2peak when compared with existing field-based assessments. An additional benefit to using the MSTP over other field based tests is its moderate-to-strong predictive validity of VT_1 / VT_2 . These measures are known to be important predictors of health

but also performance-related fitness such as tactical and technical motor skill proficiency (Roman, Molinuevo & Quintana, 2009).

Limitations that have been reported in previous studies for investigating cardiorespiratory fitness measures include the sampling bias towards fit healthy children, who may be thought to enjoy the rigorous testing procedures of measuring aerobic performance more than unfit children. The participants in this study were representative of the Australian population for BMI with approximately a quarter of participants overweight or obese and a mean overall BMI just above the 50th percentile (Department of Health, Australian Government, 2008). The mean motor skill proficiency of the study group was slightly over the 50th percentile indicating average motor proficiency, suggesting that there was no sampling bias towards children with higher or lower mean motor scores (e.g. balance, coordination, or strength and agility) that may have contributed to higher or lower running economy. Further to defying the possibility of a sampling bias in our study, the mean $\text{VO}_{2\text{peak}}$ (43.8 ± 11.2 mL/kg/min) of our participants was compared to the means reported in previous studies using treadmill testing with children of similar age which ranged from 41 – 53 mL/kg/min (Armstrong, Williams, Balding et al, 1991; Rogers, Olson & Wilmore, 1995). These results support our assertion that there is no sampling bias towards fit, healthy children in our study.

It is acknowledged by the authors that the MSTP involves some additional skills of grasping to pick up the bean bag and increased agility for turning and changing direction more often than the 20m MSRT; however, these were purposeful inclusions in the protocol to better engage young children in the activity, as it creates a more task-oriented approach to the measure and is likely to promote engagement with the activity. Further to supporting the use of the MSTP is the consideration of the complexity of the reported equations for estimating VO_2 peak from the 20m MSRT. Previous prediction equations have all used complex mathematical systems / formulas to determine $\text{VO}_{2\text{peak}}$ (Leger et al, 1988; Barnett et al, 1993; Matsuzaka et al, 2004).

As in the present study, gender, age, body mass and height were not significant predictors of VO_2peak in the presence of MSTP, these variables are not required in the MSTP equation for estimating VO_2peak expressed relative to body mass. This means that the MSTP equation is simpler and can be easily and quickly calculated without having to undertake other measures such as height, body mass, BMI, or skin folds. This is noteworthy, as the process of taking body measurements in school environments is a sensitive issue and with studies reporting fitness as a health variable that is independently associated with clustered cardiovascular disease risks (Andersen, Sardinha, Froberg et al, 2008), the need to take children's body measurements in schools to assess cardiovascular health status could potentially be eliminated by using the MSTP.

6.7 LIMITATIONS

Although the results of this study suggest there is no sampling bias towards fit, healthy children, there is a bias towards male participants and the overall sample size is small. Each of these factors may affect the generalisability of the findings from this study. Additionally the consolidation of testing for children in this study, where all testing was completed on a single day with only 1 hour wash out periods between strenuous tests could have impacted on the participants' performance in some of the measures. Additionally, the order of testing, where the 20m MSRT was the first test for all children, could have influenced the results in this study.

6.8 CONCLUSIONS

In conclusion, the MSTP was found to be a valid measure of cardiorespiratory fitness with a high predictive validity for estimating VO_2peak in children using a simple to apply equation. Data from this study suggest that the MSTP could be considered, as a more appropriate (valid and suitable) measure to use than the 20m MSRT for predicting VO_2peak in child and adolescent populations, particularly considering the

sensitivities of measuring cardiorespiratory fitness in groups of children with diverse fitness abilities (e.g. school environments). Further research is required to establish the test-retest reliability of the MSTP and its external validity, in order to examine the extent to which the results of this study can be generalised to children outside of the study group and to other populations (i.e. adults). Additionally, a larger cross-sectional study is required if normative values are to be developed for the MSTP. Overall, the MSTP provides a valid and alternative measure for assessing aerobic fitness in children, particularly when working with sensitive populations in large groups.

6.9 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 7.

VALIDATING THE SPEED AND AGILITY MOTOR SCREEN (SAMS) AS A MOTOR PERFORMANCE-RELATED FITNESS MEASURE FOR CHILDREN

7.1 PRELUDE

This chapter contributed to Stage 2 – *Taking Action: Screening Tool Development* for this doctoral research program. Specifically it was the second step in validating the newly designed measures for inclusion in the KidFit Screening Tool. The Speed and Agility Motor Screen (SAMS) is a quick-to-apply, valid and reliable measure for screening motor performance-related fitness in children and should be considered by PE teachers, coaches and health professionals when concerns exist regarding motor proficiency as a possible contributor to a child's excess adiposity or reduced cardiorespiratory fitness. At the time of this thesis submission this study was in review with the Journal of Australian Strength and Conditioning. This chapter represents the study works prior to the review process by this journal. To review the published (and fully edited) version of this chapter please access the following publication:

Milne N, Hing W. (2014). Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children. *Journal of Australian Strength and Conditioning (Online)*, 23, (2), 6-14.

A video of the instructions for this test has been created for the online publication and can be viewed at: <http://www.strengthandconditioning.org/> . The SAMS is the performance-related fitness measure to be included in the KidFit Screening Tool.

7.2 ABSTRACT

Aims: This study aimed to assess the test-retest reliability and concurrent-validity of the Speed and Agility Motor Screen (SAMS) as a motor-performance-related fitness measure for children and determine if the SAMS could better predict poor motor-proficiency in overweight/obese children compared to the general paediatric population. The final aim was to establish if a SAMS cut-off time could be determined to identify children who may benefit from further investigation of their gross-motor skills.

Methods: A concurrent validity and test-retest reliability study design was implemented with a convenience sample of 233 school-aged children (n=M-120;F-113), aged 5-17 years (Mean \pm SD:11.44 \pm 2.18yrs), from public, Catholic and Independent schools. Completed measures included: Bruininks-Oseretsky-Test-of-Motor-Proficiency-2nd Edition (BOT2) and the SAMS. A representative sample (n=77) also completed Body-Mass-Index (BMI) measurements (Mean \pm SD: BMI percentile = 50.27 \pm 30.86).

Results: Results indicate a strong test-retest reliability of the SAMS (ICC=0.87, 95% CI: 0.710, 0.816). The motor components of balance (15.8%), bilateral-coordination (2.8%), strength (18.7%), running-speed and agility (22.9%) were all significant contributors to the SAMS completion time. The SAMS had low-to-moderate predictive-validity for determining gross-motor ability in the general population of children (r^2 =0.214, p =0.00) but a strong predictive-validity with overweight/obese children (r^2 =0.641, p =0.001). Children who took \geq 5.43s to complete the SAMS had significantly lower motor proficiency than children who took <5.43s.

Conclusion: The authors conclude that the SAMS is a valid and reliable screening measure that can be used to predict poor gross-motor proficiency in overweight/obese children. The SAMS is designed to be used in conjunction with health-related fitness measures, by those who work with children (e.g. coaches, Health and Physical-Education teachers, health professionals) when concerns exist regarding motor-

proficiency as a possible contributor to poor health and fitness and to guide referral decisions.

Key words: Child, speed, agility, motor proficiency, fitness, health

7.3 INTRODUCTION

In order to be physically active during childhood, children require the attributes of both health-related fitness (i.e. cardiorespiratory endurance) as well as performance-related fitness (i.e. motor proficiency; balance, coordination, speed and agility). Cardiorespiratory fitness (CRF) has been strongly associated with cardiovascular disease risk factors in both children and youth and this association is independent of age, sex and country of residence (Anderssen, Cooper, Riddoch et al, 2007). Additionally, CRF has been firmly established as a predictor of all-cause mortality in adult men and women (Kodama, Saito, Tanaka et al, 2009). Such research has led to the development of a number of valid and reliable, non-invasive field tests for estimating CRF (i.e. VO_2) in children, adolescents and adults. However, growing evidence suggests that exercise capacity (i.e. the combined attributes of health and performance-related fitness) decreases all-cause mortality (Lee & Skerrett, 2001) independent of adiposity (McAuley, Kokkinos, Oliveira et al, 2010). Exercise capacity is therefore dependent not only on one's CRF but also their ability to develop and utilize motor proficiencies to enhance opportunities for movement and physical activity. Thus, there are potential health benefits to be gained through the development of paediatric-specific motor screening measures.

Motor proficiency has been shown to significantly impact upon the likelihood of participation in physical activity (Smyth & Anderson, 2000), overall performance on cardiovascular fitness tests (Hands & Larkin, 2006; Cairney, Hay, Faught et al, 2007) and the extent of excessive weight and obesity (Faught, Hay, Cairney et al, 2005). Gross-motor proficiency typically includes measures of balance, coordination, strength, speed and agility (Bruininks & Bruininks, 2005). However, very few tests have been

developed to screen (as opposed to thoroughly measure) motor performance-related fitness in children. Those tools that do exist are often expensive, require clinical expertise to implement and take lengthy periods to score before results are available to individuals. A screening measure for motor performance-related fitness that could be coupled with a screening measure for CRF could be used to assist with identifying children who have reduced motor skill proficiency which may be associated with, or an underlying cause of, their reduced CRF or obesity. Such a screening tool could be termed a speed and agility test, as this area of performance-related fitness requires the screening of motor skills related to balance, coordination, speed and strength in a snap shot. Speed and agility tests represent a measure of one's ability to move quickly whilst controlling and coordinating the large musculature required to move through a defined movement or locomotion that is important for recreational activity, exercise and/or competitive sports. As such, a screening measure of motor performance-related fitness could be used by coaches, health and physical education (HPE) teachers and health professionals to identify children who could benefit from detailed assessment and intervention, to enhance the health and motor performance-related fitness of children.

The Speed and Agility Motor Screen (SAMS) which incorporates a time-motion measure, has been specifically designed to screen motor performance-related fitness in children. The theoretical rationale for the development of this screening measure was that those who work with children (e.g. Coaches, HPE teachers, and Health-professionals) could use the SAMS result to assist with making decisions about the contribution of motor proficiency to poor health and fitness. This information could be used to guide decisions about intervention and referral for specialized assessments (e.g. paediatric physiotherapists for detailed motor assessment) with the expectation that such a referral would assist with early intervention and prevention of the onset of chronic disease for children with poor health and fitness. It is a very quick to administer screening measure that is thought to include components of speed and agility, whole body coordination, core strength and balance; all components known to

individually challenge overweight and obese children (Haga, 2009). This study aims to: i) Assess the test-retest reliability of the SAMS; ii) Test the concurrent validity of the SAMS as a motor performance-related fitness measure for children, against the Bruininks Oseretsky Test of Motor Proficiency, 2nd Edition (BOT2) (Bruininks et al, 2005) gross-motor subtests; iii) Determine if the SAMS could better predict poor motor-proficiency in children who are overweight or obese compared to the general paediatric population and iv) Establish if a cut-off time for the SAMS could be determined to identify children who may benefit from further investigation of their gross-motor skills.

7.4 METHODS

Approach to the Problem: This study was a concurrent validity and reliability study of 233 children from public, Catholic and Independent Education Schools across South-East Queensland, Australia. Motor proficiency using the BOT2 and a newly designed motor performance-related fitness screening test (SAMS) were the main measures collected in this study. Anthropometric data was also collected on a representative sample of children, in order to examine if the validity of the SAMS was improved when implemented with overweight or obese children. Data was collected at a local school camp, at Bond University or on the school grounds.

Participants: Two hundred and thirty-three children (age: 5 to 17yr), including 120 boys and 113 girls were recruited to participate in the research activities via advertisement to local schools, community flyers and word of mouth. Eligible participants were attending school, were at least 5 years old and no older than 17 years. Children diagnosed with mobility limiting orthopaedic or neurological conditions were excluded from participating as they would not have been able to validly complete the standardised motor assessment. Bond University Human Research Ethics Committee approved the study protocols (RO1601, RO1019). Packages including explanatory statement, informed consent and parent database

forms were sent to parents via the school principal. Parents were given the chance to read, sign and return the forms to the research team consenting for their child to participate in the research activities during regular school time or during their time on school camp as a prescheduled activity.

Procedures: Children were timetabled into the research activities during a planned visit to the school, at Bond University research labs or during their school camp. During their visit, they were randomly allocated into small groups (no more than 4 children per group) to complete the activities and were rotated from one activity station to the next. Stations were manned by trained research assistants and the study coordinator. Teachers from the participants' schools were in the room during all of the testing for children completing the study at the school camp and parents were invited to sit in on the sessions when the participants completed the activities at Bond University or at the schools. Anthropometric measures were collected in addition to the motor assessments with children attending Bond University or an Independent or Catholic education school (n=77). Height and weight measurements were taken individually behind a privacy screen, so that other children were unable to observe the measures. Standing height was measured barefooted, on a solid surface using a tape measure to the nearest 0.5cm. Weight was measured with participants wearing shirt and shorts, using calibrated digital weight scales (HD-366, Tanita Corporation, Tokyo, Japan). Children were asked to step onto the scales backwards and a screen over the display was used to shield the children from viewing their weight measurement. The height and weight measurements were used to calculate BMI raw scores and BMI percentiles.

The BOT2 was chosen as the reference measure of Motor Proficiency for this study based on its widespread international use and previously determined validity and reliability for measuring motor ability (Bruininks et al, 2005). The BOT2 takes approximately one hour to administer and is a diagnostic and evaluative tool that includes a combination of fine and gross motor subtests and was used in this study to assess motor proficiency of all participants. The Fine Motor Precision (drawing,

cutting, folding paper) and Fine Motor Integration (copying shapes through drawing on paper) subtests combine to make up *Fine Manual Control*. Manual Dexterity (timed tests using hands including making dots in circles, transferring coins from one container to another, placing pegs into a pegboard, sorting cards and stringing blocks) and Upper Limb Coordination (catching, throwing and dribbling a tennis ball) subtests combine to make up *Manual Coordination*. Both Fine Manual Control and Manual Coordination standard scores were used in combination with gross motor subtests to assist with determining overall motor proficiency only. The BOT2 gross motor subtests include Bilateral Coordination (touching nose with index fingers and eyes closed, jumping jacks, synchronized and non-synchronized jumping, coordinated finger and toe tapping sequences) and Balance (timed activities of standing feet apart on a line and a beam, heel toe on a line and a beam, with eyes open and eyes closed and walking on a beam) subtests which make up *Body Coordination*. Additionally the gross motor subtests of Running Speed and Agility (timed activities including; a sprint shuttle run, repeated sequence of stepping sideways over a balance beam, one legged hopping, one legged side hopping and two legged side hopping) and Strength (standing long jump, push-ups, sit-ups, wall sit and prone extension) combine to make up *Strength and agility*. The sum of *Fine Manual Control*, *Manual Coordination*, *Body Coordination* and *Strength and Agility* composite scores make up *Total Motor Proficiency*. Standardised instructions and scoring methods were applied in the assessment process as per the BOT2 assessment manual (Bruininks et al, 2005), with the exception of the order of testing, which was scheduled into a rotational timetable for groups of children to complete the assessment process. All research team members collecting BOT2 data were required to have an allied health, psychology or education qualification with a license to practice or were directly supervised by such professionals.

The SAMS is a short timed measure that has been newly designed for screening motor performance-related fitness with children in a snapshot. To complete the SAMS, the child moves from standing with hands by side, to laying prone with hands above head

and feet together, then rolling as a log 360 degrees, standing up and performing a jumping jack (2-stage star jump). During the study, the children were verbally instructed on how to complete the SAMS and then offered one practice in slow motion with feedback provided on modifications if required. After the child understood how to complete the SAMS, they were asked to do it as fast as they could using a “ready, go” trigger. The time was stopped when the child returned to the start position of standing with hands by side and feet together. After a 30 second rest, participants were offered a second trial. If the participant did not complete the task correctly (e.g. got up before rolling 360 degrees or did not have hands above their head when rolling), then the SAMS was explained again and they were offered a re-trial. The time was recorded for the SAMS 1st Trial and SAMS 2nd Trial.

Statistical Analysis: All data were analysed using SPSS Version 21. Descriptive statistics including proportions and means based on raw scores and percentile ranks were used to describe the Body Mass Index (BMI) category, motor proficiency and time for completion of the SAMS. Statistical significance was set at $p < 0.05$. Participants were analysed as a whole group and also in groups divided by BMI category (<85th BMI percentile = non overweight or obese group and; $\geq 85^{\text{th}}$ BMI percentile = overweight or obese group). Time to complete the SAMS was based on 1SD below the mean SAMS completion time. Independent samples *t* tests were used to determine if differences existed in BOT2 scores and SAMS time between groups. The test-retest reliability of the SAMS was assessed over a one minute period using Intraclass Correlation Coefficients (ICC). The concurrent validity of the SAMS 2nd trial was analysed using Pearson’s Product Moment Correlations, with raw scores of the subtests of the BOT2 that were deemed to be consistent with the attributes of the SAMS (Bilateral Coordination, Balance, Running Speed and Agility and Strength Total Point Scores). Linear regression analysis was used to calculate the degree by which individual gross-motor subtest results of the BOT2 contributed to the SAMS completion time. In order to determine if the SAMS could be a quick to apply, valid measure for screening children’s overall gross-motor ability, a multiple regression analysis was undertaken.

This analysis aimed to reveal if certain combinations of BOT2 gross-motor skills (Bilateral Coordination, Balance, Strength and Running Speed and Agility) had a stronger relationship with the SAMS than individual gross-motor measures and if the addition of anthropometric measures (e.g BMI) would further enhance this relationship. Power analyses were performed using an effect size calculator (Ellis, 2014) and G-power Software, Version 3.1.7 (Faul, Erdfelder, Buchner et al, 2009). This was performed post-hoc as no data previously existed for the SAMS. In order to guarantee statistical power above 80% and considering the following: 1) a 1-tailed α value of 0.05, 2) subgroup sample sizes of 14 (overweight and obese) 3) 63 (non-overweight or obese) an effect size (d) of at least 0.75 was required to conduct independent samples t tests for assessing differences between BMI category groups. A further power analysis for the correlation statistics revealed that with a sample of 77 participants, and a 1-tailed α value of 0.05 and an expected effect size of at least $r = 0.28$, a statistical power of 80% can be achieved.

7.5 RESULTS

Table 7.1 provides the gross-motor and anthropometric characteristics of the 233 study participants (Mean age: 11.44 ± 2.18) and includes the mean scores for the SAMS 1st and 2nd trials. Additionally, the mean Total Motor Proficiency percentile rank for children in the study was assessed to be 66.88 ± 26.80 , indicating that overall the study population had 'average' motor skill ability with a wide range of motor proficiency from 'well-below average' to 'well-above average'. Table 7.1 also provides the results for the Independent t tests that were undertaken to examine differences in motor proficiencies between participants with a BMI percentile < 85th versus those \geq 85th revealing significant differences in all motor areas except Bilateral Coordination. Of the 233 children who participated in this study, a representative sample of 77 (33%) children underwent anthropometric assessment and this subset of children had a relatively even representation of public ($n=36$) and Independent/Catholic ($n=41$) education backgrounds. The mean BMI for the total group is shown in Table 7.1 and

was in the 'healthy weight' category but results ranged from underweight to morbidly obese. Fourteen of those measured anthropometrically were overweight or obese (22%) according to BMI percentiles. This figure is consistent with the Australian population of approximately 23% children being overweight or obese (Department of Health, Australian Government, 2007).

Table 7.1 Gross-motor scores and anthropometric characteristics of participants.

Variable	Total Group	BMI Percentile < 85th	BMI Percentile ≥ 85th	Comparison between groups	
	Score (<i>M</i> ± <i>SD</i>)	Score (<i>M</i> ± <i>SD</i>)		Effect size (<i>d</i>)	<i>p</i> - value
BOT2 Gross Motor Measures	(<i>n</i> = 233)	(<i>n</i> = 63)	(<i>n</i> = 14)		
Bilateral Coordination (no.)	22.10 ± 3.43	21.62 ±3.67	23.00 ±1.57	-0.49	0.175
Balance (no.)	33.21 ± 3.83 *	33.00 ±3.65	30.57 ±3.46	0.68	0.026
Running Speed and Agility (no.)	38.57 ± 6.10 **	38.73 ±5.38	33.43 ±6.89	0.85 [#]	0.002
Strength (no.)	29.12 ± 5.79 **	30.83 ±5.09	25.71 ±5.34	0.98 [#]	0.001
SAMS	(<i>n</i> = 233)	(<i>n</i> = 63)	(<i>n</i> = 14)		
1st Trial (s)	4.73 ± 0.91 **	4.41 ±0.80	5.49 ±1.26	-1.02 [#]	0.000
2nd Trial (s)	4.42 ± 1.01 **	4.05 ±0.69	5.35 ±2.29	-0.77 [#]	0.000
Anthropometric Measures	(<i>n</i> = 77)	(<i>n</i> = 63)	(<i>n</i> = 14)		
BMI (kg / m ²)	18.72 ± 5.62 **	17.23 ± 2.46	25.38 ± 9.87	-1.13 [#]	0.000
BMI Percentile	50.27 ± 30.86 **	40.90 ± 25.92	92.43 ± 5.11	-2.76 [#]	0.000

** Independent *t* test between participants with BMI Percentile < 85th and participants with BMI Percentile ≥ 85th is significant at the *p* = 0.01 level (2-tailed).

* Independent *t* test between participants with BMI Percentile < 85th and participants with BMI Percentile ≥ 85th is significant at the *p* = 0.05 level (2-tailed).

[#] Over the 80% threshold for guaranteeing sufficient statistical power.

(No.) Refers to the raw scores of the BOT2 for each subtest.

All children completing the SAMS were able to correctly complete the measure after no more than 2 practice trials. No children in the study reported any discomfort or injury whilst completing the SAMS. Age was not a significant predictor of SAMS completion time ($r^2 = 0.00$, $F(1,231)$, $p = 0.96$) and results were therefore not analysed by age categories. The test-retest reliability of the SAMS was measured over a 1 minute period (SAMS 1st trial compared to SAMS 2nd trial) and was found to be strong with an ICC=0.87, (95% CI: 0.830, 0.899). Figure 7.1 illustrates the Bland and Altman plot between the 1st and 2nd SAMS trials.

Figure 7.1 95% Limits of Agreement for the Speed and Agility Motor Screen (SAMS) 1st and 2nd Trials.

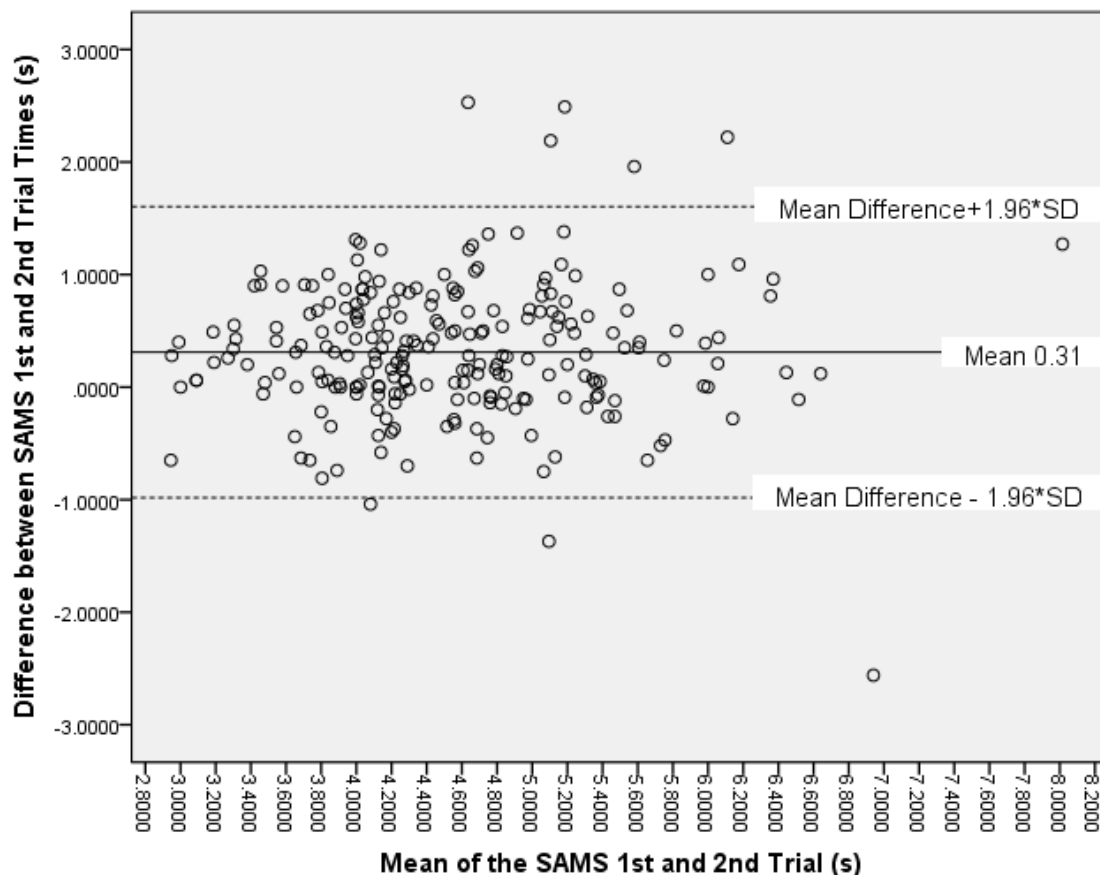


Table 7.2 Pearson correlations and linear regression coefficients between the Speed and Agility Motor Screen (SAMS) and Gross-Motor Performance variables of the Bruininks-Oseretsky Test of Motor Proficiency - 2nd Edition (BOT2).

BOT2 Variables	Total Group		Participants Measured Anthropometrically			
	All Study Participants (n=233)		BMI Percentile < 85th (n=63)		BMI Percentile ≥ 85th (n=14)	
	r	r ²	r	r ²	r	r ²
Bilateral Coordination	-.167* (.011)	.028* (.011)	-.183 (.151)	.033 (.151)	.158 (.590)	.025 (.590)
Balance	-.398** (.000)	.158** (.000)	-.296* (.018)	.088* (.018)	-.723** (.003)	.523** (.003)
Running Speed & Agility	-.478** (.000)	.229** (.000)	-.444** (.000)	.197** (.000)	-.696** (.006)	.484** (.006)
Strength	-.433** (.000)	.187** (.000)	-.402** (.001)	.162** (.001)	-.758** (.002)	.575** (.002)
Combined Gross Motor Skills	-.463** (0.000)	.214** (.000)	-.409** (.000)	.167** (.001)	-.801** (.000)	.641** (.001)

The level of significance for each value is shown in brackets.

**Pearson Correlation is significant at the 0.01 level (2-tailed) / Linear Regression is significant at the 0.01 level (1-tailed).

*Pearson Correlation is significant at the 0.05 level (2-tailed) / Linear Regression is significant at the 0.05 level (1-tailed).

BOT2 Combined Gross Motor Skills = Bilateral Coordination + Balance + Running Speed and Agility + Strength.

Table 7.2 demonstrates the relationship between the SAMS and gross-motor performance measures of the BOT2. Low to moderate correlations exist between the SAMS and any single gross-motor subtest of the BOT2, with balance, strength and running speed and agility having a stronger relationship with the SAMS than bilateral coordination. In order to determine the contribution of the BOT2 gross-motor

components (balance, coordination, strength, running speed and agility) to the SAMS, linear regression analyses were undertaken, showing that all gross-motor components were significant contributors (see Table 7.2).

The contribution of the individual gross-motor measures; balance, strength and running speed and agility to the SAMS increased considerably when linear regression coefficients were determined for the children in the overweight and obese group (i.e. BMI Percentile \geq 85th) (see Table 7.2). When the individual gross-motor subtest scores were combined to make up a single BOT2 Gross-Motor score, the predictive validity of the SAMS as a standalone measure increased from a low to moderate predictive validity in the total group ($r^2 > 0.2$, $p < 0.01$) to a high predictive validity ($r^2 > 0.60$, $p < 0.01$) for children with a BMI Percentile \geq 85th (i.e. children who are overweight or obese).

Finally, multiple regression analysis revealed that for the total group, a model including independent measures of strength, balance, bilateral coordination and running speed and agility accounted for 30.1% of the variance of the SAMS ($r^2 = 0.308$, $F(4, 228)$, $p < 0.001$) and the addition of BMI raw score to this model accounted for 71.3% of the variability of the SAMS ($r^2 = .713$, $F(5,71)$, $p < 0.001$). For children who had a BMI percentile \geq 85th, the same model accounted for 78.3% of the variance of the SAMS ($r^2 = .783$, $F(4,9)$, $p = 0.005$) and with BMI raw score added to the model, it accounted for 92.3% of the variability of the SAMS ($r^2 = 0.923$, $F(5,8)$, $p < 0.001$).

A cut-off time for the SAMS was calculated (5.43s) by adding 1SD to the mean SAMS completion time for the study population. Children who completed the SAMS in under 5.43s ($n = 206$) had a mean Total Motor Proficiency percentile rank of 70.53 ± 24.31 compared to the significantly lower percentile rank of 38.69 ± 28.87 for children ($n=27$) who took ≥ 5.43 s to complete the SAMS ($t = 6.145$, $DF=225$, $p < 0.001$). Significant differences were found between the two groups (i.e. SAMS < 5.43 s; SAMS ≥ 5.43 s) for all individual components of gross-motor proficiency: Bilateral Coordination ($t = 3.390$,

DF = 231, $p = 0.001$); Balance ($t = 5.297$, DF = 231, $p < 0.001$); Running Speed and Agility ($t = 6.535$, DF = 231, $p < 0.001$) and Strength ($t = 5.526$, DF = 231, $p < 0.001$). Additionally, children who took less than 5.43s to complete the SAMS had a mean BMI of 17.85 ± 2.94 (kg/m²) compared to 27.41 ± 14.28 (kg/m²) for children who took ≥ 5.43 s to complete the SAMS.

7.6 DISCUSSION

In this study we aimed to assess the test-retest reliability and the concurrent validity of the SAMS as a motor-performance-related fitness measure for children. Additionally we aimed to determine if the SAMS could better identify poor motor proficiency in children who are overweight or obese compared to the general paediatric population. Finally we aimed to establish if a cut-off time for the SAMS could be determined so that coaches, health and education professionals could use the measure to identify children who may benefit from further investigation of their gross-motor skills to enhance their physical fitness.

The prominent findings of the present study were that a quick to apply screening measure of motor performance-related fitness (i.e. SAMS) that was designed for use with child and adolescent populations in a refined space such as clinical rooms, had a high test-retest reliability and was a strong predictor of gross-motor ability when coupled with the health-related measure of BMI. This finding is important for clinical practice, given that the SAMS: i) can be performed in a small space (i.e. 3m x 3m room); ii) requires only a mat on the ground and a stop-watch with no specialised or expensive equipment; iii) takes no more than 1 minute to complete with no additional complicated scoring methods; iv) provides information (i.e. a cut off time) that can be used to inform decisions about referrals for more detailed assessments and intervention. These factors are critical if any test is going to be used as a screening measure, as expense, time and space are all issues that impact on choices to use certain tools in clinical practice to assist with referral decisions.

It is known that motor proficiency significantly impacts on the likelihood of a child participating in physical activity (Smyth et al, 2000), their cardiovascular fitness (Hands et al, 2006; Cairney et al, 2007) and the extent of excessive adipose tissue (Faught et al, 2005). Consequently, the clinical relevance of determining one's motor performance-related fitness is well established. Despite this, there are many limitations to performing detailed standardised motor assessments, including the burden of expensive and specialised equipment, which requires professional expertise to administer over an extensive period (i.e. over 1 hour to apply and in excess of 30 minutes to score), resulting in reduced access to objective information about motor proficiency for coaches, HPE teachers and primary health professionals. The possible consequence of this lack of information, is that a one size fits all model will be instigated, where either all children with a BMI above the 85th percentile (i.e. overweight or obese) will be referred to specialised services for motor assessment or no children will be considered for this layer of investigation.

The results of the present study suggest that the SAMS which was designed to be used as a discriminative measure, is a valid and reliable screening measure of motor performance-related fitness and its predictive validity is highest when used with children who are overweight or obese. Therefore, those who work with children in physical activity domains who are concerned that motor proficiency may be a contributing factor to a child's apparent excess adiposity or poor CRF, could use the SAMS to assist with making decisions about referring children to specialist services, such as paediatric physiotherapists, for more detailed assessment and intervention of motor proficiency as required. Specifically, if a child had a BMI above the 85th percentile and took longer than 5.43 seconds to complete the SAMS, a referral could be initiated for further investigation of motor skill proficiency. These findings directly address the first three of our study aims.

The final aim of this study was to establish a cut-off time for the SAMS that would

provide a clear and objective time point for clinicians to use, to justify a referral to specialised health professionals to further investigate the child's motor proficiency and to determine if it is a contributing factor to their overweight/obesity or reduced CRF. The time of 5.43s represents 1SD slower than the mean completion time of the SAMS and was a cut-off point that drew statistically significant differences in all four BOT2 gross-motor components; bilateral coordination, balance, strength and running speed and agility. As such this cut-off time was deemed indicative of below-average motor proficiency; warranting further detailed motor assessment for the child who takes 5.43s or longer to complete the SAMS.

It is important to note that the test–retest reliability results of the SAMS were not expected to be perfect due to a probable learning effect from the 1st to the 2nd trial of the SAMS, which is evidenced in Table 7.1; showing a reduced mean SAMS time in the 2nd trial. Despite this, the results are better than the test–retest reliability results for the BOT2 mean subtest correlations determined in the development phase of the BOT2 that were between 0.65 and 0.74 (Bruininks et al, 2005). With this knowledge, it would be appropriate to ensure that in any future administration of the SAMS that all children be given a trial test with the second measure being the recorded result. Future research is required to investigate if the SAMS learning effect is capped with a few trials. Further if a child is either internally or externally motivated to continue practicing the SAMS, could a training effect improve their time? It is likely that the child could improve their SAMS completion time with repeated practice; however such practice is also likely to enhance their overall gross motor proficiency on formal standardised motor assessments such as the BOT2.

Although a possible limitation that only 77 of the subject BMI was measured, the participants in this study were found to be representative of the Australian population for both motor proficiency and BMI, with a relatively equal distribution of male and female participants, suggesting there was no sampling bias within the study population.

There are no known previous studies that have investigated the validity or reliability of motor performance-related fitness measures specifically for use with overweight or obese children and there are no known tools that have been developed to assist with guiding the referral pathway for detailed assessment of motor performance-related fitness in children. This study therefore provides coaches, HPE teachers and health professionals who work with children, particularly those who are overweight or obese, with a new screening tool that can quickly, validly and reliably identify children whose motor proficiency is below average and may be contributing to their excess adiposity or reduced CRF. A larger cross sectional study is required to establish normative values and to determine the external validity of the SAMS, in order to examine the extent to which the results from this study can be generalized to other populations (i.e. adults). Additionally, further research is needed to determine the validity and utility of the SAMS as a talent identification measure where it could be used to differentiate children who may be very fast to complete the SAMS and potentially athletically gifted.

7.7 CONCLUSIONS

The SAMS can be considered a quick to apply, valid and reliable measure for screening motor performance-related fitness in children, particularly with children who are overweight or obese. The SAMS should be considered for use by those who work with children (e.g. coaches, HPE teachers, health professionals) when concerns exist regarding motor proficiency as a possible contributor to a child's excessive adiposity or reduced CRF and to guide referral decisions. Specifically, a child aged 5 – 17 years with a BMI above the 85th percentile (overweight or obese) who takes longer than 5.43 seconds to complete the SAMS, should be considered for a referral to specialist services for further investigation of motor skill deficiencies.

7.8 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 8.

DIAGNOSTIC ACCURACY OF THE KIDFIT SCREENING TOOL FOR IDENTIFYING CHILDREN WITH AND WITHOUT HEALTH AND MOTOR PERFORMANCE-RELATED FITNESS IMPAIRMENTS: A FEASIBILITY STUDY

Milne N, Leong, GM, Hughes R, Hing W (2014). Diagnostic accuracy of the KidFit Screening Tool for identifying children with and without health and motor performance-related fitness impairments: a feasibility study.

(To be submitted for journal publication post acceptance of the study in Chapter 6)

8.1 PRELUDE

This chapter presents the culminating study for this doctoral research program and contributed to Stage 3 in the development of the KidFit Screening Tool. Specifically, this study involved a secondary analysis of the combined data from earlier studies (Chapters 6 and 7) to evaluate the predictive validity and diagnostic accuracy of the combined measures that make up the KidFit Screening Tool. As this chapter makes reference to the MSTP (Chapter 6) and the SAMS (Chapter 7) throughout the manuscript, it will be submitted to a journal for publication only after both Chapters 6 and 7 have been accepted for publication. A number of statistical measures have been undertaken in this study to assess the sensitivity and specificity and subsequently the accuracy of the KidFit Screening Tool for identifying children who have poor health and/or performance-related fitness. A number of issues relating to the utility of the KidFit Screening Tool are discussed in this feasibility study.

8.2 ABSTRACT

Aims: In order to assess the feasibility of using the KidFit Screening Tool to identify children who could benefit from specialised assessment and interventions relating to motor proficiency and physical fitness, this study aimed to i) assess the predictive validity of the KidFit screening tool as a measure of health and performance-related fitness for children and ii) assess the accuracy of the KidFit screening tool for identifying children with overweight or obesity, reduced motor skills and reduced cardiorespiratory fitness.

Methods: Data from fifty-seven children (mean age: 12.57 ± 1.82 years; male/female: 34/23) who participated in two previously reported cross sectional studies were analysed. Children completed the following measures: Speed and Agility Motor Screen (SAMS) and the Modified Shuttle Test-Paeds (MSTP) to make up the KidFit Screening Tool and motor proficiency (BOT2) ($n=57$). The additional measures of BMI, peak oxygen uptake (VO_{2peak}) were also undertaken with a representative sample ($n=25$).

Results: Mean BMI percentile: 51.84 ± 33.94 , mean motor proficiency percentile rank: 61.42 ± 30.46 . Strong and significant relationships existed between the KidFit Screening Tool and; BMI ($r^2=0.779$, $p < 0.001$); Gross Motor Proficiency ($r^2=0.612$, $p < 0.001$) and VO_{2peak} (mL/kg/min) ($r^2=0.754$, $p < 0.001$). The KidFit Screening Tool had a correct classification rate of: 0.84 for overweight and obesity, 0.77 for motor proficiency and 0.88 for cardiorespiratory fitness. The sensitivity and specificity of the KidFit Screening Tool for identifying children with: i) overweight or obesity was 100% (SE= 0.00) and 78.95% (SE=0.09); ii) motor skills in the lowest quartile was 90% (SE=0.095) and 74.47% (SE=0.064) and iii) poor cardiorespiratory fitness was 100% (SE=0.00) and 82.35% (0.093). Receiver operating characteristic curve (ROC) analysis revealed that the area under the curve (AUC) was 0.895 for overweight and obesity, 0.822 for motor proficiency and 0.912 for cardiorespiratory fitness.

Conclusions: The KidFit Screening Tool has a strong and significant relationship with health and performance-related fitness measures of BMI, VO_{2peak} and Gross Motor Proficiency and was found to be moderately to highly accurate for identifying children with and without overweight or obesity, motor skills in the lowest quartile and/or poor

cardiovascular fitness. This screening information could be a valuable tool for informing decisions regarding referral to specialised services for detailed investigation of underlying reasons for the poor health and/or performance-related fitness.

Key Words: KidFit, Screening, Health, Fitness, Motor Proficiency, Children.

8.3 INTRODUCTION

The rising prevalence of obesity over recent decades and the current rates of child obesity in Australia and internationally remain a concern for health and education workers and policy makers alike. Child overweight and obesity is associated with poor health outcomes such as insulin resistance, Type 2 diabetes mellitus (T2DM), hypertension, dyslipidaemia and fatty liver disease (Lee, 2009). Further association has been shown with idiopathic intracranial hypertension (Sugerman, Demaia, Felton et al, (1997) and obstructive sleep apnoea (Mallory, Fiser, Jackson, 1989; Marcus, Curtis, Koerner et al, 1996; Silvesti, Weese-Mayer, Bass et al, 1993) which can result in daytime somnolence and neurocognitive deficits such as reduced concentration and poor memory (Redline & Stroghl, 1999; Rhodes, Shimoda, Waid et al, 1995). Some researchers believe these neurocognitive deficits, may be responsible for the relationship between Body Mass Index (BMI), an indicator of excess adiposity among children (Freedman & Sherry, 2009), and academic achievement (Taras & Potts-Datema, 2005) however, recent research indicates an absence of any relationship between school literacy and numeracy and percentage body fat, after adjusting for socioeconomic status (Telford, Cunningham, Telford et al, 2012). Conversely, physical activity and cardiorespiratory fitness (CRF) have both been positively linked to cognitive processes and brain function in children, with aerobically fitter children performing better on cognitive function tasks (Davis, Tomporowski, Boyle et al, 2007; Tomporowski, Davis, Miller & Naglieri, 2008).

Physical activity has been firmly associated with health-related fitness (Janssen & LeBlanc, 2010) as well as motor proficiency (Wrotniak, Epstein, Dorn et al, 2006; Barnett, van Beurden, Morgan et al, 2009; Stodden, Goodway, Langendorfer et al, 2008). However, to be physically active, children require the underlying motor skills that enable them to take up physical activity in order to develop or maintain good health-related fitness and consequently enhance opportunities for positive educational outcomes.

With exercise capacity being known to decrease all-cause mortality (Lee & Skerrett, 2001) independent of adiposity (McAuley, Kokkinos, Oliveira et al, 2010) a screening tool that does not require physical body measurements such as BMI, but rather focuses on CRF and motor performance-related fitness could be used by health and education professionals to identify children who could benefit from specialist assessment and interventions relating to motor proficiency and physical fitness.

The KidFit Screening Tool has been sensitively designed for this purpose and includes the combination of two simple measures: i) Modified Shuttle Test-Paeds (MSTP) – a health-related CRF measure (Milne, Simmonds & Hing – Chapter 6) and; ii) the Speed and Agility Motor Screen (SAMS) – a quick to apply timed motor performance-related fitness measure which includes components of speed and agility, whole body coordination, core strength and balance (Milne & Hing, 2015); all components known to individually challenge overweight and obese children (Haga, 2009). Therefore, in order to test the feasibility of using the KidFit Screening Tool to identify children who could benefit from specialised assessment and interventions relating to motor proficiency and physical fitness, the aims of this study were to i) assess the predictive validity of the KidFit Screening Tool as a measure of health and performance-related fitness for children and ii) assess the accuracy of the KidFit screening tool for identifying children with overweight or obesity, reduced motor skills and reduced CRF.

8.4 METHODS

Data from fifty-seven children (age: 6-17yr; male/female: 34/23) who were recruited via community flyers, advertisement to local schools and word of mouth to participate in previously reported studies were used for this study. To be eligible for inclusion to the present study, children needed to be aged between 5 and 17 years inclusive and attending school at the time of testing. Children who were unable to complete the testing due to mobility limiting orthopaedic or neurological conditions were excluded from the present study. Informed participant assent and parent/legal guardian consent were obtained for all children who participated. Bond University Human Research Ethics Committee reviewed and approved the experimental protocols from which the data in this study was collected (RO 1601, RO1019).

Experimental Design

Data from two previously reported studies (Milne & Hing 2015; Milne et al, Chapter 6) were combined for analysis in the present study. All measures were undertaken at either the participant's school or Bond University research lab. Prior to their testing session, participants were familiarised with the experimental protocol and equipment to be used. Parents were invited to observe their child's participation. Children who met the above stated inclusion and exclusion criteria and had completed the measures of motor proficiency (BOT2), Speed and Agility Motor Screen (SAMS) and the Modified Shuttle Test-Paeds (MSTP) were included in this study (n=57). The measures of height, weight and peak oxygen uptake (VO_{2peak}) were also undertaken with participants who attended the appointments at Bond University research labs (n=25) as these measures were not approved to be taken in school environments.

Procedures

Motor Skill Proficiency (BOT2 and SAMS)

The Bruininks Oseretsky Test of Motor Proficiency, 2nd Edition (BOT2) is an internationally recognised discriminative normative referenced tool that has been previously validated and found to be reliable for assessing the motor proficiency of

children aged 4.5 – 17 years (Bruininks & Bruininks, 2005). The BOT2 was used to assess the fine and overall motor proficiency of children in this study. Standardised instructions and scoring methods were applied for all BOT2 subtests as per the assessment manual (Bruininks et al, 2005) with the only exception being the order of testing which was planned around the CRF measures. All BOT2 motor subtest scores were combined to determine a BOT2 percentile rank and this information was used to sub-classify participants into BOT2 quartile groups ((1st Motor Quartile Group - 0 to ≤ 25% (lowest); 2nd Motor Quartile Group - >25% to ≤ 50%; 3rd Motor Quartile Group - >50% to ≤ 75% and 4th Motor Quartile Group - >75% to ≤ 100% (highest)).

The Speed and Agility Motor Screen (SAMS) is a valid and reliable measure that has been previously reported to predict poor gross-motor proficiency in overweight / obese children (Milne et al, 2015). To complete the SAMS, the participants were instructed to move from standing with hands by side, to laying prone on a 5cm thick mat with hands above head and feet together, log roll 360 degrees, stand up and perform a jumping jack (2-stage start jump) and to do this as quickly as they could. All participants were given a practice trial before a timed trial using a “ready, go” trigger. After 30 seconds rest, the participants were offered a second timed trial and this was the SAMS time used for the present study.

Anthropometric measurements

Standing height was measured at the top of tidal inspiration on a solid surface with children in bare feet, using a tape measure to the nearest 0.5cm. Body mass was measured in kilograms using calibrated scales with children wearing light clothing (e.g. shorts and shirt). Children were blinded to their weight measurements using a shield over the display. Height and weight measures were subsequently used to calculate BMI (raw scores and percentiles) using CDC growth charts (Centers for Disease Control and Prevention, 2014).

Cardiorespiratory Fitness (CRF) (VO₂peak and MSTP)

Peak oxygen uptake (VO₂peak) was determined on a motor-driven treadmill ('Valiant'; Lode B.V., Groningen, Netherlands) via an incremental exercise test to volitional fatigue. The protocol involved predetermining a preferred walking speed of between 4.0-5.0 km/h at 0% grade to start the test and then increasing the speed every 60 s until the participant reached their previously determined comfortable running speed which was between 6.0-8.0 km/h for all participants. The treadmill grade was then increased every 60 seconds by 1% for younger children (≤ 12 years) and 2% for adolescent (>13 years) participants until the participant could no longer continue. Breath-by-breath values for oxygen uptake (VO₂), minute expired ventilation and carbon dioxide output (VCO₂) were measured using a calibrated open-circuit metabolic measurement system (Ultima CPX, Medical Graphics Corporation, St Paul, USA). A 12-lead ECG (Cardio Perfect, Welch Allyn Inc., Skaneateles Falls, USA) was used to monitor cardiac rhythm throughout the test. To calculate the peak exercise values, the average of the two highest 30 s values measured before test discontinuation were used.

The Modified Shuttle Test-Paeds (MSTP) is a valid field measure of CRF with a high predictive validity for estimating VO₂peak in children (Milne et al, Chapter 6). The MSTP involves the children running a straight 10 metre shuttle, picking up 1 hand-held bean bag from a tray on the ground, turning around and returning to the start point to place the bean bag into an identical size tray on the start line and repeating this as many times as they can in 3 minutes. Strong verbal encouragement is offered to the children in the test to enhance the likelihood of maximal effort being achieved. For every bean bag returned to the tray the child receives one (1) point and for any additional bean bag that the child may have picked up but not yet returned to the tray they receive a further half (1/2) point.

KidFit Screening Tool

The KidFit Screening Tool is made up of two of the above mentioned measures: i) SAMS using a previously reported cut-off time of ≥ 5.43 s to indicate concerns with

motor skills, in particular speed and agility (Milne et al, 2015) and ii) MSTP using a previously determined equation for predicting VO_2max (ml/kg/min) in children (Milne, et al, Chapter 6) which then allows the CRF of children to be classified as very poor, poor, fair, good, excellent or superior (cut-off values for those considered to have reduced CRF ≤ 34.9 mL/kg/min for girls and ≤ 45.1 mL/kg/min for boys) (The Cooper Institute for Aerobics Research, 1997). Children with a MSTP predicted VO_2max in the very poor, poor, or only fair categories would be indicated as needing further assessment to investigate reasons for reduced CRF. When the KidFit Screening Tool is applied any child who takes ≥ 5.43 s to complete the SAMS and/or has a MSTP predicted VO_2max under the above mentioned cut-off ranges would be identified as KidFit +ve; needing further detailed assessment by a suitably qualified health professional (e.g. paediatric physiotherapists) to work towards improving a child's health and performance-related fitness to prevent the onset of associated chronic disease.

Statistical Analysis

Means and standard deviations were calculated for all measures collected. Percentages and frequencies were also calculated for all physiological and anthropometric measures. Independent samples *t* tests were used to determine if differences existed between girls and boys for each of the health and performance-related fitness measures. Multiple regression analysis was used to determine if a relationship existed between the combined measures that make up the KidFit Screening Tool and BMI, motor proficiency and VO_2peak . To assess the diagnostic accuracy of the KidFit Screening Tool, sensitivity, specificity, positive and negative predictive values, positive likelihood ratios (LR+), negative likelihood ratios (LR-), efficiency rates (ER) and odds ratios (OR) were calculated for the combined tests that make up the KidFit Screening Tool (Kraemer, 1992). Receiver operating characteristic (ROC) curves were plotted for each of the state variables (BMI, Motor Proficiency and VO_2peak) so that the balance of sensitivity and specificity could be assessed using the area under the curve (AUC) using methods outlined by Swets (1988). These measures

assist with determining the diagnostic accuracy of the KidFit Screening Tool for identifying children with: BMI percentiles in the overweight or obese category; Motor Proficiency in the first (lowest) quartile and; reduced cardiorespiratory fitness (i.e. VO₂peak in the very poor, poor or fair categories using cut-off values provided by The Cooper Institute for Aerobics Research, 1997). The narrative analysis for diagnostic decision making was also applied using the criteria reported previously by Thorne, Coggins, Olson and Astely (2007) as outlined in the Table 8.1. All data were analysed using SPSS Version 21.

Table 8.1 Criteria applied for levels of evidence for a reasonable diagnostic screening measure using the Area Under the Curve (AUC).

Level of Evidence	Criteria
Random Accuracy	AUC < 0.5
Poorly Accurate	AUC = 0.5-0.7
Moderately Accurate	AUC = 0.7-0.9
Highly Accurate	AUC = 0.9-1.0

Fisher's exact test was performed to determine if the classification variables ((BMI percentiles in the overweight or obese categories, Motor Proficiency in the first (lowest) BOT2 quartile and reduced CRF (VO₂peak in the fair, poor or very poor which equates to the cut-off values of ≤ 34.9 mL/kg/min for girls and ≤ 45.1 mL/kg/min for boys)) were significantly associated with the KidFit Screening Tool. Statistics were analysed with SPSS for Windows (Version 21.0) in addition to a spread sheet for the calculation of comprehensive statistics for the assessment of diagnostic tests and inter-rater agreement (Mackinnon, 2000). Significance level was set at $p < 0.05$.

8.5 RESULTS

Fifty-seven children (Mean age: 12.57 ± 1.82 years) participated in this study with a mean total motor percentile rank in the average range but 10 (17.54%) children in the lowest motor quartile (0 to $\leq 25\%$). BMI was calculated for just under half ($n=25$) of children who participated in this study and of these children the majority ($n=16$, 64%) were in the healthy weight range, with 12% ($n=3$) underweight and 24% ($n=6$) overweight or obese. This figure is consistent with the Australian reference data of approximately 1 in every 4 children being overweight or obese (Department of Health, Australian Government, 2008).

The same 25 children whose BMI was measured, also undertook an incremental exercise test to determine their peak oxygen uptake (VO_{2peak}). One child however, was unable to complete the treadmill test due to a cardiac anomaly being detected on 12-lead ECG early in the test administration. The mean VO_{2peak} for girls (41.32 ± 3.55 ml/kg/min) is considered to be in the 'excellent' range whereas the mean VO_{2peak} for boys (45.06 ± 12.53 ml/kg/min) was considered to be in the 'good' range using reference data from The Cooper Institute for Aerobics Research (1997).

There were no significant differences between boys and girls in this study for any raw scores in the health or performance-related measures. However, there was a significant difference in age between girls and boys ($t = -2.59$, $DF=55$, $p=0.012$) with the mean age of girls being 1.21 years younger than boys in the study. Additionally, there was a significant difference between girls and boys in the Total Motor Proficiency Percentile Ranks ($t=2.42$, $DF=55$, $p=0.019$) where female participants had a mean total motor proficiency percentile rank 19 points higher than the male participants after age was factored into the calculation, indicating that overall the girls in this study had significantly better motor skills for their age than the boys.

Table 8.2 provides the means and standard deviations for the health and performance-related fitness characteristics of participants included in this study. The predictive

relationship between the KidFit Screening Tool and BMI; Motor Proficiency; and VO₂peak for children in this study is provided in Table 8.3.

Table 8.2 Means and Standard Deviations for Health and Performance-related Fitness Measures

Variable	Participant Numbers	Mean ± SD
MSTP (No.)	57	21.83 ± 2.93
MSTP Predicted VO ₂ peak (mL/kg/min)	57	43.63 ± 9.16
VO ₂ peak (mL/kg/min)	24	44.12 ± 11.02
VO ₂ peak (mL/min)	24	2294.85 ± 828.85
Total Motor Percentile Rank (BOT2)	57	61.42 ± 30.46
SAMS (s)	57	4.68 ± 1.40
BMI raw score (kg/m ²)	25	20.96 ± 8.75
BMI percentile	25	51.84 ± 33.94
BMI Z score	25	0.11 ± 1.40

Data presented as mean ± SD. MSTP: Modified Shuttle Test – Paeds, MSTP Predicted VO₂max using the predictive equation provided in Chapter 6, VO₂peak: peak oxygen uptake, BOT2: Bruininks Oseretsky Test of Motor Proficiency, 2nd Edition, SAMS: Speed and Agility Motor Screen, BMI: Body Mass Index.

NOTE: Mean BMI raw scores and percentiles in addition to the VO₂peak (mL/kg/min) have been previously reported in Chapter 6.

Table 8.3 Multiple Regression Coefficients (r^2) between the KidFit Screening Tool and BMI, VO₂peak and Motor Proficiency.

Variable	Regression Coefficients	Significance
	r^2	p value
BMI (kg/m ²)	.779**	<0.001
BOT2 Total Motor (Raw Score)	.494**	<0.001
BOT2 Total Gross Motor (Raw Score)	.612**	<0.001
VO ₂ peak (ml/kg/min)	.754**	<0.001

BMI: Body Mass Index. BOT2 Total Motor: includes all subtest raw scores including Fine Motor Precision, Fine Motor Integration, Manual Dexterity, Upper Limb Coordination, Bilateral Coordination, Balance, Running Speed and Agility, Strength. BOT2 Total Gross Motor: includes gross motor subtest raw scores including Bilateral Coordination, Balance, Running Speed and Agility, Strength. VO₂peak: Directly measured peak oxygen consumption during a graded exercise test on a treadmill.

* Regression Coefficient is significant at the 0.05 level.

** Regression Coefficient is significant at the 0.01 level.

Table 8.4 details the diagnostic accuracy of the KidFit Screening Tool for identifying children with: overweight and/or obesity; Motor Proficiency in the 1st (Lowest) Motor Quartile according to BOT2 results and; low CRF (VO₂peak in the very poor, poor or fair categories: Girls cut-off = MSTP Predicted VO₂peak ≤ 34.9 mL/kg/min; Boys cut-off = MSTP Predicted VO₂peak ≤ 45.1 mL/kg/min). Table 8.5 provides the output from the Receiver Operating Curves (ROC), including the area under the curve (AUC), which shows that that KidFit Screening Tool has 'moderate to high' accuracy for identifying children with and without overweight or obesity, poor motor skills and/or poor CRF.

Table 8.4 Diagnostic accuracy parameters of the KidFit Screening Tool

Health or Performance-related fitness measure	Cell Counts				Diagnostic Accuracy Parameters								
	TP	FN	FP	TN	Sensitivity (SE)	Specificity (SE)	PPV (SE)	NPV (SE)	LR+ (95% CI)	LR- (95% CI)	OR (95% CI)	ER	Fisher's Exact Test p value
BMI ($\geq 85^{\text{th}}$ Percentile) Overweight or Obese) (n=25)	6	0	4	15	100% (0.00)	78.95% (0.093)	60% (0.153)	100% (0.00)	4.75 (1.99-11.35)	0.00 (-)	44.78 (2.10-956.84)	0.84	<0.001
Motor Proficiency (1 st Motor Quartile) (n=57)	9	1	12	35	90% (0.095)	74.47% (0.064)	43% (0.108)	97% (0.027)	3.53 (2.07-5.99)	0.13 (0.02 – 0.87)	26.25 (3.00 – 229.34)	0.77	<0.001
VO ₂ peak (ml/kg/min) (n=24)	7	0	3	14	100% (0.00)	82.35% (0.093)	70% (0.145)	100% (0.00)	5.67 (2.03-15.82)	0.00 (-)	62.14 (2.82 – 1367.82)	0.88	<0.001

Abbreviations: TP: true positives; FN: false negatives; FP: false positives; TN: true negatives; CI: confidence interval; PPV: positive predictive value; NPV: negative predictive value; LR+: positive likelihood ratio; LR-: negative likelihood ratio; OR: odds ratio; ER: Efficiency Rate. All P-values for the OR were <0.05 (significant).

Table 8.5 Output from the Receiver Operating Curves (ROC) for determining the accuracy of the KidFit Screening Tool for identifying children with and without overweight or obesity, poor motor skills and/or poor cardiorespiratory fitness.

State Variable	AUC	SE	CI	P value
BMI (Percentile)	.895**	.063	.771, 1.00	0.004
Motor Proficiency (BOT2 Percentile)	.822**	.069	.688, .957	0.001
CRF (VO ₂ peak)	.912**	.060	.794, 1.00	0.002

AUC: Area Under the Curve; SE: Standard Error; CI: Confidence Intervals; P values: Significance levels; VO₂peak: Peak Oxygen Uptake as a measure of cardiorespiratory fitness (CRF) measured in mL/kg/min); BMI: Body Mass Index;

**p values are significant at the 0.01 level.

8.6 DISCUSSION

The present study tested the feasibility of using a screening tool to identify children with reduced health and performance-related fitness. Specifically, this study aimed to determine if a relationship existed between the collective components of the newly designed KidFit Screening Tool and the health and performance-related fitness measures of BMI, CRF and motor proficiency in children. Additionally the present study aimed to assess the accuracy of the KidFit Screening Tool in identifying children who; are overweight or obese, have reduced motor skills and/or have reduced CRF.

The results of this study indicate that the KidFit Screening Tool has a strong and significant relationship with the health-related fitness measures of BMI and VO₂peak. Additionally the KidFit Screening Tool was found to have a strong and significant relationship with gross motor proficiency but only a moderately strong relationship with overall motor proficiency (which is inclusive of gross and fine motor skills). These results address the first of our study aims to assess the KidFit Screening Tool as a measure of health and performance-related fitness for children. These results are

important as they suggest that the measures included in the KidFit Screening Tool (MSTP and SAMS) when used together, provide a valid predictor of both health and motor performance-related fitness in children which supports the feasibility of using the tool for the purpose as suggested above.

With regards to the second of our study aims, the results of this research provide preliminary evidence that the KidFit is a feasible tool for screening children, that is moderately to highly accurate in identifying those who are overweight or obese, have motor skills in the lowest quartile and / or poor cardiovascular fitness. With sensitivity ranging from 90 – 100% and specificity ranging from 74 – 82% in addition to a correct classification rate of 0.77 – 0.88 for a test that takes less than 5 minutes to complete, the KidFit Screening Tool could be considered just as good, if not better than other previously reported screening measures for identifying children with poor health and motor-performance-related fitness. For example, Kroes, Vissers, Sleijpen et al (2004) reported on the screening test; Maastricht's Motor Test (MMT) for distinguishing children with abnormal motor behaviour from those with normal motor behaviour, reporting 86% sensitivity and 70% specificity for the MMT. Although there are many standardised motor assessments for children with the concurrent and predictive validity and reliability documented, there is little documented research investigating the sensitivity and specificity of the measures for accurately identifying children and adolescents with poor motor skills. Conversely, a number of CRF measures have been developed to assist with identifying children with higher cardiovascular disease (CVD) risk factors with sensitivity documented between 33.3 – 100% and specificity rates between 34.0 – 92.1% (Bergmann, Bergmann, Moreira, 2013). The KidFit Screening Tool is at the upper end of these values for both sensitivity and specificity, adding to the worth and feasibility of the tool.

Impaired motor skills that limit a child's ability to be physically active can reduce CRF (Cairney, Hay, Faught et al, 2007) and CRF is associated with poor health outcomes leading to chronic disease (Lee, 2009). Additionally, aerobically fitter children are

more likely to achieve on cognitive function tasks (Davis et al, 2007; Tomporowski et al, 2008) and healthy weight children tend to attain better academic outcomes at school (Taras et al, 2005). For these reasons, early identification of children with poor health and motor-performance-related fitness is critical. Early identification can assist with timely referral to specialised services for intervention, to prevent or ameliorate the onset of chronic disease and or associated adverse psychosocial / learning outcomes for the child. The KidFit Screening Tool can be utilised with children individually or in large groups and could be considered a feasible tool to assist with this early identification. It is a quick and easy to administer test with high sensitivity and specificity, therefore the authors recommend that the KidFit Screening Tool be used by Physical Education (PE) teachers, coaches or health clinicians who work with children in various settings, to assist with screening their health and motor performance related fitness. Implementation of such screening could help with making decisions regarding early referrals to specialised services (e.g. paediatric physiotherapists) for i) detailed investigation of underlying reasons for reduced motor proficiency or CRF and ii) intervention to prevent the onset of associated chronic disease, or any negative psychosocial / learning outcomes.

8.7 LIMITATIONS

The present study has some notable limitations that should be considered when interpreting the results. Firstly, the study cohort is small with less female participants than males and females having higher motor proficiency (once corrected for age) than male participants, which may limit the generalisability of the study findings to a wider population. Secondly, despite numerous studies reporting children's CRF levels, including directly measured and predicted VO_2max , there remains a lack of consensus amongst researchers and clinicians on appropriate cut-off values for accurately identifying CVD risk factors in children, particularly very young children. The VO_2peak cut-off values for the KidFit Screening Tool in the present study (Girls: MSTP Predicted $\text{VO}_2\text{peak} \leq 34.9 \text{ mL/kg/min}$; Boys: MSTP Predicted $\text{VO}_2\text{peak} \leq 45.1 \text{ mL/kg/min}$) were

derived from reference data produced by the Cooper Institute for Aerobics Research (1997), which is based on children aged 13 – 19 years. These VO₂max categories and cut-off values for identifying children with reduced CRF in this study are however, consistent with the cut-off values identified by Bergmann et al, (2013) in a review of procedures for the creation of CRF cut-off points for children and adolescents. Cut off values to accurately identify children and adolescents with increased likelihood of developing cardiovascular disease risk factors have been shown to range between 33.0 and 40.1 ml/kg/min for females and 37.6 and 46.0 ml/kg/min for males (Bergman et al, 2013) which are inclusive of the cut-off values used in the present study.

8.8 CONCLUSIONS

In summary, the KidFit Screening Tool has a strong and significant predictive relationship with health and performance-related fitness measures of BMI, VO₂peak and Gross Motor Proficiency and is moderately to highly accurate for identify children with and without overweight or obesity, motor skills in the lowest quartile and/or poor cardiovascular fitness. This screening information can be used to inform decisions regarding referral to specialised services for detailed investigation of underlying reasons for poor health and/or performance-related fitness. The KidFit Screening Tool therefore presents as a feasible and accurate tool which provides an important contribution to the early identification of poor health and motor performance-related fitness in children so that users can instigate early intervention and prevention of associated chronic disease. The authors caution users in interpreting the results of the KidFit Screening Tool as a standalone assessment and recommend that the results of the KidFit Screening Tool be interpreted as the first line of assessment and in the context of further examination.

8.9 REFERENCES

References for this study can be found in the full reference list in Chapter 10 of this thesis.

CHAPTER 9.

DISCUSSION AND CONCLUSIONS

9.1 DISCUSSION

Child obesity is a common condition with approximately 13% of children and adolescents in developing countries reported to be overweight or obese and approximately 23% of children in developed countries now overweight or obese (Ng, Fleming, Robinson et al, 2014), which was consistent with the prevalence rates reported for Australian children in 2004 (Lobstein, Baur, Uauy, 2004). The current age-standardised national estimates for Australasia, however, which factor in Australia and New Zealand are slightly higher with approximately 25% of boys and 24% of girls overweight or obese (Ng et al, 2014). Between 1980 and 2013, the worldwide prevalence of overweight and obesity combined in children rose by 47.1% (Ng et al, 2014). During the time that we have seen obesity rates increase, population-wide surveys have demonstrated decreased cardiorespiratory fitness in paediatric populations (Tomkinson, Leger, Olds, Cazorla, 2003) with habitual levels of physical activity (PA) declining (Brownson, Boehmer, Luke, 2005). The decreasing levels of PA could be seen as a cause or consequence of overweight and obesity, however, the literature investigated in Chapter 2 of this thesis demonstrates that most targeted intervention regarding PA is focused at a one size fits all, population-level approach to reducing sedentary behaviours (e.g. screen time) and increasing physical activity generally for children. Little focus is given to an individual child-centred approach, investigating motor skills as an underlying deficiency that may contribute to a child's inactivity and or poor health-related fitness. Motor proficiency has been shown to significantly impact upon the likelihood of participation in physical activity (Smyth and Anderson, 2000), overall performance on cardiovascular fitness tests (Hands and Larkin, 2006; Cairney, Hay, Faught et al, 2007) and the extent of excessive weight and obesity (Faught, Hay, Cairney and Flouris, 2005). Additionally, a study that investigated the PA

levels and self-efficacy of children with Developmental Coordination Disorder (DCD) suggested that children with DCD were less likely to be physically active and that lower generalised self-efficacy could account for a considerable proportion of these findings (Cairney, Hay, Faught et al, 2005).

With such high rates of overweight and obesity, Australia should be bracing itself for a tsunami of unprecedented poor health, economic, educational and social outcomes that obesity and its associated sequelae are evidenced to produce. Preventive initiatives to reduce the impact are obviously needed. However, simply encouraging young children to be physically active, may not overcome the burden of our society's obesogenic environments, as those children who need to improve their levels of PA most, may not possess the motor proficiency required to undertake and enjoy PA.

The main objective of this PhD research program was the development of a screening tool that could be used for early identification of children who possess attributes that are associated with overweight and obesity, specifically to identify children with reduced cardiorespiratory fitness and/or reduced motor proficiency. The KidFit Screening Tool was developed for use by persons who typically work with children (such as PE teachers, coaches or health professionals). It can be used to assist professionals working with children to make informed decisions about referral to specialised services (e.g. paediatric physiotherapy) for detailed assessment of a child's motor skills as a potential contributing factor to their poor health-related fitness or inactivity. The development of the KidFit Screening Tool was undertaken across three defined stages which are discussed below:

Stage 1 – Needs Assessment

Stage 1 incorporated a 'needs assessment' which involved a detailed review of the literature and a national survey of physiotherapists working with children. The national survey was reported in Chapter 3 and provided information about the perceived needs of physiotherapists to enhance physiotherapy service delivery to

overweight and obese children. The survey results revealed that although physiotherapists are servicing overweight and obese children, very little clinical time is dedicated to their needs with less than half of physiotherapists assessing the motor proficiency of the overweight and obese children they encountered (Milne, Low Choy, Leong, Hughes and Hing, 2015). The literature review presented in Chapter 2 of this thesis, provided information suggesting there was an association between obesity and fundamental movement skills, and reduced cardiorespiratory fitness. However the literature that existed at the time of the review had limitations, in that previous studies had not assessed the relationship between motor proficiency using internationally recognised or standardized motor assessment tools that were discriminative in nature whilst directly measuring cardiorespiratory fitness (i.e. VO_2peak). This gap in the literature was addressed in stage 2 of this doctoral research.

Stage 2 – Taking Action: Screening Tool Development.

The information gathered in the survey and in the literature review guided development of a Data Collection Sheet (see Appendix 2) which comprised of new measures to be included in the KidFit Screening Tool (MSTP, SAMS, ULFT) and gold standard reference measures for motor performance and health-related fitness. Prior to substantial data collection a quality assurance step of assessing the inter-tester reliability between assessors was undertaken (see Chapter 4). Also during this stage, a study which investigated the relationship between motor proficiency and health-related fitness using the gold standard reference measures was undertaken. In Chapter 5 of this thesis, motor proficiency, once corrected for age, was shown to be significantly ($r^2 > 0.6$) related to a number of health-related fitness measures. These included BMI, waist circumference and cardiorespiratory fitness (peak oxygen consumption) with strength and running speed and agility found to be the strongest contributors to the relationship between motor proficiency and these health-related fitness measures. Furthermore, children in the lowest motor quartile were found to have significantly larger waist circumference, and BMI ($p < 0.05$).

A major focus of this stage of screening tool development was assessing the psychometric properties for each of the newly designed measures proposed for inclusion in the KidFit Screening Tool.

The Modified Shuttle Test Paeds (MSTP) was a newly designed alternative measure of cardiorespiratory fitness for children (see Chapter 6). This measure was designed with an awareness of the sensitivities around using 'drop out' measures with children and knowledge of the extensive time, space and or equipment required for alternative cardiorespiratory fitness measures. Chapter 6 shows that the MSTP was found to be a valid measure of cardiorespiratory fitness with a high concurrent and predictive validity for estimating VO_2peak in children ($r^2=0.749$, $p<0.001$) using a simple clinically applicable equation. For this reason it was deemed appropriate to be included in the KidFit Screening Tool.

The SAMS (Speed and Agility Motor Screen) was thought to be made up of gross motor components including strength, whole body coordination, speed, agility and balance (see Chapter 7). Results from the study presented in Chapter 7 indicate that the SAMS had a strong test-retest reliability ($\text{ICC}=0.87$, 95% CI: 0.710, 0.816) and the gross motor components of balance, bilateral-coordination, strength and running-speed and agility were all significant contributors to the test. The SAMS was shown to have a strong predictive validity for estimating gross motor ability with overweight and obese children ($r^2=0.641$, $p=0.001$) and for this reason it was also deemed appropriate to be included in the KidFit Screening Tool.

The third new measure was an upper limb flexibility measure (ULFT), however, after completion of reliability testing (see Chapter 4), the upper limb flexibility measure was shown to have only moderate reliability between testers and as flexibility had not previously been shown to be associated with obesity, this measure was excluded from this research.

Each of the chapters included in stage 2 of screening tool development (Chapters 4, 5, 6 and 7) assisted to make decisions about inclusion and exclusion of measures to be incorporated in the refined KidFit Screening Tool. The refined KidFit Screening Tool included two measures: The MSTP (a cardiorespiratory fitness measure) and the SAMS (a speed and agility motor measure). This refined tool was used in stage 3 of this doctoral research to evaluate the predictive validity and diagnostic accuracy of the KidFit Screening Tool.

Stage 3 – Evaluating the Action (The KidFit Screening Tool)

During the various stages of data collection for this PhD research program, it became very evident that there were extreme sensitivities and considerable resistance in the education sector to taking body measurements of children in school environments, despite providing safe and private settings to undertake these assessments. Although there is no evidence to say that taking body measurements will cause any detrimental effects if done sensitively and in a health promoting environment, there is evidence to suggest that children who are obese already have increased anxiety, depression and negative self-image (Ebbeling, Pawlak and Ludwig, 2002). So it is perhaps understandable that those who work with children in schools act to protect their students by blocking any persons undertaking body measurements in the school environment. Consideration of this resistance, gave premise to the belief that the KidFit Screening Tool, if to be taken up by PE teachers, needed to include measures that were typical of day to day activities for children and could be easily implemented in a school environment without a ‘hands on’ approach to any individual child.

Therefore, Chapter 8 of this thesis examined the predictive validity and diagnostic accuracy (including sensitivity and specificity) of the refined KidFit Screening Tool for identifying children with overweight or obesity, reduced motor skills and/or reduced cardiorespiratory fitness. The refined version of the KidFit Screening Tool was made up of the combined measures of the SAMS (a motor performance-related fitness measure) and the MSTP (a health-related fitness measure) as an overall screening

measure of exercise capacity. The results of this study provided in Chapter 8 revealed that by using designated cut-off values for the SAMS and MSTP, the KidFit Screening Tool had good-to-excellent accuracy for identifying children with and without: overweight/obesity; motor skills in the lowest quartile and/or; poor cardiorespiratory fitness, which addresses the overall objective of this PhD research program.

9.2 STRENGTHS AND LIMITATIONS

Prior to undertaking this doctoral research a review of the literature revealed a gap in the approach that was being taken to working with overweight and obese children. In particular this was in the domain of PA where the impact of motor proficiency appeared to be a missing link in the assessment and management of children and adolescents who were overweight or obese. This research aimed to address some of the gaps that existed in this area. Since the initial review of the literature, the National Health and Medical Research Council have released the new Clinical Practice Guidelines for the management of overweight and obesity in adults, adolescents and children in Australia (NHMRC, 2013). Notably, in this document the main points in the section titled 'Assessing children and adolescents who are overweight or obese' now includes some key points that are directly relevant to physiotherapists: abnormal gait, difficulties with balance and coordination as well as problems with feet, hips and knees or hip and knee joint pain (NHMRC, 2013). Each of these problems could contribute to reduced exercise capacity and warrant detailed examination.

The World Confederation for Physical Therapy advocates the role and scope of physical therapists to be about: developing, maintaining and restoring maximum movement and functional ability (including motor proficiency) across the lifespan when movement and function are threatened or impaired by disease, disorders, conditions or environmental factors (WCPT, 2013). Although conditions such as joint pain are likely to stimulate an acute referral to physiotherapy, abnormal gait and difficulties with balance and coordination are less likely to stimulate a referral to physiotherapy

until they are seen to be causing obvious functional deficits. The KidFit Screening Tool provides a measure that can be applied to school-aged children and findings from this research indicate it could identify a number of these issues early and perhaps before they are obvious enough to have stimulated an independent referral to physiotherapy.

The practice of applying a tool that discriminates children who are fit from those who are not (as done in this research) may be criticised by some persons who are protective of the wellbeing of children. It is important to point out that this research does not aim to compound any of the psychosocial issues already apparent in many overweight or obese children (Ebbeling, Pawlak and Ludwig, 2002). Consequently, any guidelines produced on the application of the KidFit Screening Tool would include the importance of applying the tool in a health-promoting mode and any referrals that occurred as an outcome of the KidFit results would need to be dealt with in a very professional and delicate manner. The emphasis of a referral would need to be on the promotion of improving the understanding around the impacts of reduced health and performance-related fitness and on the prevention of any associated health, psychosocial or educational sequelae. This could be achieved through a goal-oriented approach to improved health rather than any form of blaming of the child or their parents/carers.

There were a number of limitations with this doctoral research that have been highlighted in each of the chapters and some that warrant brief discussion at this point. Firstly, recruiting school aged children for participation in a study that required body measurements (height, weight and waist circumference) was exceptionally difficult as the local public education sector would not support the participation of their students in a study that included body measurements. This meant that in order to participate, children from the public education sector were required to attend the testing at the university, which meant that there remained a risk throughout the research studies that a recruitment bias (towards children who were particularly motivated to undertake the measures and were perhaps more fit and motor proficient) may have

occurred. Continual monitoring of the health and motor proficiency status of participants was crucial to ensure that a participation bias towards fit, healthy children was eliminated as an issue through targeted recruitment. Recruitment of children through both non-treatment and intervention studies ensured a diverse participant base for this doctoral research. Another limitation to this research is the limited participant numbers in some of the studies / chapters, in particular the lower number of female participants. As some of the studies required the children to be removed from class time and the studies undertaken at the university required hours of participation, a number of parents who enquired about the study chose not to consent for their child to participate, particularly when there was no intervention being offered for the child after the collection of data. As such the generalisability of the findings in some of the studies in this doctoral research cannot be assumed. A final limitation of this research is the absence of physical activity as an included measure, considering the strong influence that physical activity can have on fitness and motor skill proficiency. One study did include this as a measurement but the results were not included in this PhD thesis. Each of these limitations and the challenges they presented will be considered in the planning of methodology for future related research.

9.3 SIGNIFICANCE OF THIS DOCTORAL RESEARCH AND FUTURE DIRECTIONS

The findings from this doctoral research have direct significance for those who are involved with the development of children's health and motor performance-related fitness. This research program is the first of its kind to explicitly investigate the links between motor proficiency and health related measures using gold standard references and to use this information to guide the development of a screening tool that is relevant to the health and performance related fitness of Australian children. In particular it is most relevant to those who work with large populations of children such as PE teachers, coaches, and health professionals and those who are likely to receive

referrals for assessing and managing children with overweight or obesity, gross motor incompetency and/or reduced cardiorespiratory fitness.

The outcomes of this research provide those who work with children, an easy to apply screening tool (KidFit Screening Tool) that can be used to inform decisions regarding referral of children with poor motor skills and/or reduced cardiorespiratory fitness to specialised services without the focus of the referral being about weight status. Specialised services may include paediatric physiotherapists or other suitably qualified professionals. These professionals can provide detailed investigation of the underlying causes for a child's deficiencies in exercise capacity so that early intervention can be instigated to enhance a child's ability to take up physical activity in the future.

The next step beyond this doctoral research is to examine the generalisability of the KidFit Screening Tool on a larger population to ensure that the accuracy that has been achieved in this doctoral research extends to a wider population of children across Australia. After this has been completed, additional research work would include trialling the KidFit Screening Tool in a large-scale study at a variety of Australian schools with varying geographical and socio-economic backgrounds. Such a study would include defined referral pathways to health-based intervention programs as part of the study methodology. Referral to agencies such as school-based physiotherapy could occur if the impairments were causing disability. Alternatively school or community programs such as those outlined by Hills (2009) could be instigated. This planned study would take into account the limitations of this doctoral research. It would also take into account previous limitations defined in a review of school-based obesity prevention programs by Kropski et al (2008) which include concerns relating to small participant numbers and poor methodology. This future study would ultimately test the utility (not just the accuracy) of the KidFit Screening Tool as one step in an intervention aimed at improving the health and performance-related fitness of children who most require this. During such a study, normative data from the KidFit Screening Tool could be collected in addition to physical activity

measures, which would enhance the ability to interpret the screening data as an independent measure.

Additionally, the KidFit Screening Tool could have a wider application than the school and health environments. A potential application includes the recruitment phase of young Defence recruits. It is critical to identify early, those recruits who may have poor health or performance-related fitness so that intensive intervention can be initiated. By ensuring that young recruits who engage in defence-related duties are adequately fit, from both health and performance perspectives, injuries can be reduced and training completion increased (Pope, Herbert, Kirwan & Graham, 1999). Concerns regarding this issue have been raised in recent literature where the US Department of Defence has instigated a comprehensive multi-sector approach to preventing child obesity due to its implications for the future health of American adults, as well as its potential and perceived impact on national security (Christeson, Clifford, Dawson Taggart, 2014). The potential for the use of the KidFit Screening Tool in identifying young Defence recruits with poor health and/or performance related fitness will also be explored in future research.

9.4 CONCLUDING STATEMENT AND KEY FEATURES

Concluding statement:

Low motor proficiency is significantly associated with overweight and obesity and reduced cardiorespiratory fitness in children, and should therefore be considered a focus for investigation for children with poor health-related fitness. Although the physiotherapy profession is well suited to work with overweight and obese children, the results of this study suggest that limited service provision is being provided to this population of children by physiotherapists in Australia. The KidFit Screening Tool has been developed to improve the early identification of children with health and performance-related fitness deficiencies to enhance early referral to physiotherapy (or other suitably qualified professionals) and the feasibility study undertaken in this research program suggests it is a valid and accurate screening tool that can be used for this purpose.

Key features of this thesis:

1. Examines the service provision of the physiotherapy profession to overweight and obesity children, investigating current trends and professional needs of physiotherapists to work with overweight and obese children.
2. Demonstrates relationships between motor proficiency and health-related measures in children.
3. Examines the validity and reliability of a number of health and performance-related fitness measures used with children.
4. Provides a screening tool (KidFit) that can be used for early identification of children with reduced health and performance-related fitness.
5. Considers the feasibility of using the KidFit Screening Tool for accurately identifying children with reduced health and/or performance-related fitness.

CHAPTER 10.

REFERENCES

Abbott R, Macdonald D, Mackinnon L, Stubbs C, Lee A, Harper C, & Davies P. (2007) *Healthy Kids Queensland Survey 2006 — Summary Report*. Queensland Health, Brisbane.

Access Economics (2008). *The growing costs of obesity in 2008: three years on*. Canberra: Diabetes Australia.

Andersen L, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, & Anderssen SA. (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *Lancet*; 368: 299-304.

Andersen L, Sardinha L, Froberg K, Riddoch C, Page A, & Andersen S. (2008). Fitness, fatness and clustering of cardiovascular risk factors in children from Denmark, Estonia and Portugal: The European Youth Heart Study. *International Journal of Pediatric Obesity*; 3:58–66.

Anderssen, SA, Cooper AR, Riddoch C, Sardinha LB, Harro M, Brage S & Andersen LB. (2007). Low cardiorespiratory fitness is a strong predictor for clustering of cardiovascular disease risk factors in children independent of country, age and sex. *European Journal of Cardiovascular Prevention and Rehabilitation*; 14(4): 526-531.

APA (2009). *Position Statement: Chronic Disease and Physiotherapy*.
<http://www.physiotherapy.asn.au/> Accessed 20th December, 2010.

APA (2010). Information sheet *Paediatrics*.

<http://www.physiotherapist.net.au/apacd/infosheet/d18.htm>

Accessed 17th December, 2010.

Armstrong N, Williams J, Balding J, Gentle P, & Kirby B. (1991). The peak oxygen uptake of British children with reference to age, sex and sexual maturity. *European Journal of Applied Physiology and Occupational Physiology*; 62(5):369 – 375.

August G, Caprio S, Fennoy I, Freemark M, Kaufman F, Lustig R, Silverstein J, Speiser P, Styne D, & Montori V. (2008). Prevention and Treatment of Pediatric Obesity: An Endocrine Society Clinical Practice Guideline Based on Expert Opinion. *Journal of Clinical Endocrinology & Metabolism*; 93(12):4576–4599.

Australian Bureau of Statistics (ABS). (2009). *National Health Survey: Summary of Results 2007-08*, Commonwealth of Australia.

<http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/4364.0Main%20Features62007-08?opendocument&tabname=Summary&prodno=4364.0&issue=2007-08&num=&view> Accessed 11 May 2009.

Australian Bureau of Statistics (ABS). (2011). *Australian Health Survey: First Results, 2011-12* (cat. no. 4364.0.55.001). Commonwealth of Australia.

[http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/1680ECA402368CCFCA257AC90015AA4E/\\$File/4364.0.55.001.pdf](http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/0/1680ECA402368CCFCA257AC90015AA4E/$File/4364.0.55.001.pdf) Accessed 10th December, 2014.

Australian Institute of Health and Welfare – AIHW (2009). *A picture of Australia's children*. Canberra: AIHW.

Austin S, Melly S, Sanchez B, Patel A, Buka S, & Gortmaker S. (2005) Clustering of fast-food restaurants around schools: a novel application of spatial statistics to the study of food environments. *American Journal of Public Health*; 95(9); 1575-81.

Barnett LM, van Beurden E, Morgan PJ, Brooks LO & Beard JR. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health*; 44:252-259.

Barnett A, Chan LY, Bruce IC. (1993). A preliminary study of the 20-m Multistage Shuttle Run as a predictor of Peak VO₂ in Hong Kong Chinese Students. *Pediatric Exercise Science*; 5(1): 42 – 50.

Beaver WL, Wasserman K, Whipp BJ. (1986). A new method for detecting the anaerobic threshold by gas exchange. *Journal of Applied Physiology*; 60: 2020-2027.

Bergmann GG, Bergmann ML, Moreira RB, Pinheiro ES, Marques AC, Hallal PC & Gaya A. (2013). Proposals of cardiorespiratory fitness classification in children and adolescents: literature review. *Brazilian Journal of Physical Activity and Health*; 18(3):273-285.

Berndtsson G, Mattsson E, Marcus C, Larsson U, (2007). Age and gender differences in VO₂max in Swedish obese children and adolescents. *Acta Paediatrica*; 96:567e71.

Biddle SJ & Asare M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *British Journal of Sports Medicine*; 45:886-895.

Biddle SJ, Gorely T, Marshall SJ, et al. (2004). Physical activity and sedentary behaviours in youth: issues and controversies. *Journal of the Royal Society of Health*; 124 (1): 29-33.

Blauw-Hospers C. & Hadders-Algra M. (2005). A systematic review of the effects of early intervention on motor development. *Developmental Medicine & Child Neurology*; 47: 421–432.

Boehmer T, Lovegreen S, Haire-Joshu D. & Brownson R. (2006). What constitutes an Obesogenic Environment in Rural Communities? *American Journal of Health Promotion*; 20(6), 411-421.

Booth M, Chey T, Wake M, Norton K, Hesketh K, Dollman J & Robertson I. (2003). Change in the prevalence of overweight and obesity among young Australians, 1969–1997. *American Journal of Clinical Nutrition*; 77:29–36.

Brownson RC, Boehmer TK, Luke DA (2005). Declining rates of physical activity in the United States: what are the contributors? *Annual Review of Public Health*; 26:421–43.

Brug J, Van Lenthe F, & Kremers S. (2006) Revisiting Kurt Lewin: How to Gain Insight into Environmental Correlates of Obesogenic Behaviors. *American Journal of Preventative Medicine*; 31(6):525–529.

Bruininks, R.H. (1978). *Bruininks-Oseretsky Test of Motor Proficiency*. Circle Pines, MN: American Guidance Service.

Bruininks RH. & Bruininks BD. (2005) *Bruininks Oseretsky Test of Motor Proficiency: Examiners Manual*. 2nd ed (BOT2). Minneapolis, MN: NCS Pearson. 263 p.

Cairney J, Hay JA, Faught BE, Wade TJ, Corna L, & Flouris A. (2005). Developmental Coordination Disorder, Generalized Self-Efficacy Toward Physical Activity, and Participation in Organized and Free Play Activities. *The Journal of Pediatrics*; 2005. 147: 4, 515-520.

Cairney J, Hay JA, Faught BE, Flouris A, & Klentrou P. (2007). Developmental Coordination Disorder and Cardiorespiratory Fitness in Children. *Pediatric Exercise Science*; 19: 20-28.

Cambach W, Wagenaar R, Koelman T, van Keimpema A, & Kemper H. (1999). The long-term effects of pulmonary rehabilitation in patients with asthma and chronic obstructive pulmonary disease: a research synthesis. *Physical Medicine and Rehabilitation*; 80:1, 103-111.

Cantell M, Crawford S. & Tish Doyle-Baker P. (2008) Physical fitness and health indices in children, adolescents and adults with high or low motor competence. *Human Movement Science*; 27(2):344-62.

Carter F, & Bulik, C. (2008) Childhood Obesity Prevention Programs: How Do They Affect Eating Pathology and Other Psychological Measures? *Psychosomatic Medicine*; 70:363–371

Castelli D, Hillman C, Buck D, & Erwin H. (2007). Physical Fitness and Academic Achievement in Third- and Fifth-Grade Students. *Journal of Sport & Exercise Psychology*; 29(2), 239-252.

Catford J, & Caterson I. (2003). Snowballing obesity: Australians will get run over if they just sit there. *Medical Journal of Australia*; 179: 577–579.

Cawley J, & Spiess K. (2008). Obesity and skill attainment in early childhood. *Economics and Human Biology*; 6, 388–397.

Centers for Disease Control and Prevention. (2014). Web site (Internet). *CDC Growth charts*, Accessed 2014 May 12. Available from: <http://www.cdc.gov/growthcharts/>

Chen L, Fox K, Haase A, & Wang J. (2006). Obesity, fitness and health in Taiwanese children and adolescents. *European Journal of Clinical Nutrition*; 60:1367e75.

Chia L, & Choa L. (2002). Effect of physiotherapy on school aged children with Developmental Coordination Disorder and Learning Difficulties: A pilot study. *Physiotherapy Singapore*; 5(4): 75 – 80.

Christeson W, Clifford K, Dawson Taggart A. (2014). *Retreat is not an option: healthier meals protect our children and our country*. Mission: Readiness. Military Leaders for Kids. Council for a strong America. Washington DC.

Colagiuri S, Lee C, Colagiuri R, Magliano M, Shaw J, Zimmet P, & Caterson D. (2010). The cost of overweight and obesity in Australia. *Medical Journal of Australia*; 192(5): pp260-264.

Cole T, Bellizzi M, Flegal K, & Dietz W. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *British Medical Journal*; 320(7244): 1240-32.

Cole T, Faith M, Pietrobelli A, & Heo M. (2005). What is the best measure of adiposity change in growing children: BMI, BMI %, BMI z-score or BMI centile? *European Journal of Clinical Nutrition*; 59, 419–425.

Cole T, Flegal K, & Nicholls D. (2007). Body mass index cut-offs to define thinness in children and adolescents. *British Medical Journal*; 335: 194.

Commonwealth of Australia, Department of Health and Ageing (2014). Does your child get 60 minutes of physical activity every day? *Australia's Physical Activity and Sedentary behaviour Guidelines for 5-12 year olds*.

Cook S, Weitzman M, Auinger P, Nguyen M, & Dietz W. (2003). Prevalence of a metabolic syndrome phenotype in adolescents: findings from the third National Health

and Nutrition Examination Survey, 1988–1994. *Archives of Pediatrics and Adolescent Medicine*; 157:821–827.

Croce RV, Horvat M, & McCarthy E. (2001). Reliability and concurrent validity of the movement assessment battery for children. *Perceptual and Motor Skills*; 93(1), 275–280.

Crowle, J, & Turner E. (2010) *Childhood Obesity: An Economic Perspective*, Productivity Commission Staff Working Paper, Melbourne.

Davis CL, Tomporowski PD, Boyle CA, Waller JL, Miller PH, Naglieri JA, & Gregoski M. (2007). Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial. *Research Quarterly for Exercise and Sport*; 78(5):510–519.

Davis CL, Tomporowski PD, McDowell JE, Austin, BP, Miller PH, Yanasak NE, Allison JD, Naglieri JA. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial. *Health Psychology*; 30(1):91-8.

Davison K, & Birch L. (2001). Childhood overweight: a contextual model and recommendations for future research. *Obesity Reviews*; 2 (3) 159–171.

Deforche B, Lefevre J, De Bourdeaudhuij I, Hills A, Duquet W, & Bouckaert J. (2003). Physical fitness and physical activity in obese and nonobese Flemish youth. *Obesity Research*; 1:434e41.

Deforche B, Hills A, Worringham C, Davies P, Murphy A, Bouckaert J, & De Bourdeaudhuij I. (2009). Balance and postural skills in normal-weight and overweight prepubertal boys. *International Journal of Pediatric Obesity*; 4(3):175e82.

Department of Health (DOH). Australian Government. (2008). 2007 Australian National Children's Nutrition and Physical Activity Survey. Available from: <http://www.health.gov.au/internet/main/publishing.nsf/Content/phd-nutrition-childrens-survey>. Accessed June 1st 2014.

D'Hondt E, Deforche B, De Bourdeaudhuij I, & Lenoir M. (2009). Relationship between motor skill and body mass index in 5- to 10-year-old children. *Adaptive Physical Activity Quarterly*; 26:21e37.

Dietz W. (1998). Health consequences of obesity in youth: childhood predictors of adult disease. *Pediatrics*; 101(S2): 518–525.

Din-Dzietham R, Liu Y, Bielo M, & Shamsa F. (2007) High Blood Pressure Trends in Children and Adolescents in National Surveys, 1963 to 2002. *Circulation*; 116; 1488-1496.

Dixon J. (2010). The effect of obesity on health outcomes. *Molecular and Cellular Endocrinology*; 316: 104–108.

Dobbins M, DeCorby K, Robeson P, Husson H, and Tirilis D. (2009). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. *Cochrane Database of Systematic Reviews*; Issue 1. Art. No.: CD007651. DOI: 10.1002/14651858.CD007651.

Dobbins M, Husson H, DeCorby K, and LaRocca RL. (2013). School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database of Systematic Reviews*; Issue 2. CD007651. DOI: 10.1002/14651858.CD007651.pub2.

Duger T, Bumin G, Uyanik M, Aki E, & Kayihan H. (1999). The assessment of

Bruininks-Oseretsky test of motor proficiency in children. *Pediatric Rehabilitation*; 3(3): 125-131.

Ebbeling C, Pawlak D & Ludwig D. (2002) Childhood obesity: public-health crisis, common sense cure. *Lancet*; 360: 473–82.

Egger G, & Swinburn B. (1997). An “ecological” approach to the obesity pandemic. *British Medical Journal*; 315: 477.

Ellis PD. *Effect size calculators*. Web site (Internet); (cited 2014 May 14). Available from: <http://www.polyu.edu.hk/mm/effectsizefaq/calculator/calculator.html>.

Eisenmann J. (2005). Waist circumference percentiles for 7- to 15-year-old Australian children. *Acta Paediatrica*; 94:1182-1185.

Esmailzadeh A, Mirmiran P, & Azizi F. (2006). Clustering of metabolic abnormalities in adolescents with the hypertriglyceridemic waist phenotype. *American Journal of Clinical Nutrition*; 83:36–46.

Faught BE, Hay JA, Cairney J & Flouris A. (2005). Increased risk for coronary vascular disease in children with developmental coordination disorder. *Journal of Adolescent Health*; 37: 376-380.

Faul F, Erdfelder E, Buchner A, Lang A.-G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analysis. *Behaviour Research Methods*; 41: 1149-1160.

Fernandez J, Redden D, Pietrobelli A, Allison D, (2004). Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. *Journal of Pediatrics*; 145:439-444.

Figuerola-Munoz J, Chinn S, & Rona R. (2001) Association between obesity and asthma in 4–11 year old children in the UK. *Thorax*; 56:133–37.

Folio M, & Fewell R. (2000). *Peabody Developmental Motor Scales* (2nd Ed.). Austin, TX: PRO-ED, Inc.

Forster A, & Young J. (2002). *The clinical and cost effectiveness of physiotherapy in the management of elderly people following a stroke*. London: Chartered Society of Physiotherapy.

Francis L, Lee Y, & Birch L. (2003). Parental weight status and girls television viewing, snacking, and body mass indexes. *Obesity Research*; 11:143-51.

Fredriks A, van Buuren S, Fekkes M, Verloove-Vanhorick S, & Wit J. (2005). Are age references for waist circumference, hip circumference and waist-hip ratio in Dutch children useful in clinical practice? *European Journal of Pediatrics*; 164:216-222.

Freedman D, Dietz W, Srinivasan S. & Berenson G. (1999). The relation of overweight to cardiovascular risk factors among children and adolescents: the Bogalusa Heart Study. *Pediatrics*; 103:1175-1182.

Freedman DS, & Sherry B. (2009). The validity of BMI as an indicator of body fatness and risk among children. *Pediatrics*; 124; S23-S24.

Gebbie K. (2000). *The Public Health Workforce: Enumeration 2000*. New York: Columbia University.

Gebbie K, & Merrill J. (2001). Enumeration of the public health workforce: developing a system. *Journal of Public Health Management and Practice*; 7(4): 8-16.

Gielen S, & Hambrecht R. (2004). The Childhood Obesity Epidemic: Impact on Endothelial Function. *Circulation*; 109: 1911-1913.

Gennuso J, Epstein L, Paluch R, & Cerny F. (1998). The Relationship between Asthma and Obesity in Urban Minority Children and Adolescents. *Archives of Pediatrics and Adolescent Medicine*; 152: 1197-1200.

Goran M, Fields D, Hunter G, Herd S. & Weinsier R. (2000). Total body fat does not influence maximal aerobic capacity. *International Journal of Obesity Related Metabolic Disorders*; 24:841e8.

Gracey, M. (1995) New World Syndrome in Western Australian aborigines. *Clinical and Experimental Pharmacology and Physiology*; 22: 220-225.

Grbich C. (1999). *Qualitative Research in Health: An Introduction*. St Leonards: Unwin and Allen.

Haga M. (2008a). The relationship between physical fitness and motor competence in children. *Child: care, health and development*, 34(3): 329–334.

Haga M. (2008b). Physical fitness in children with movement difficulties. *Physiotherapy*, 94: 253–259.

Haga M. (2009). Physical fitness in children with high motor competence is different from that in children with low motor competence. *Physical Therapy*; 89: 1089-109.

Hands B & Larkin D. (2006). Physical Activity Measurement Methods for Young Children: A comparative study. *Measurement in Physical Education and Exercise Science*; 10 (3): 203-214. 2006.

Hassan M. (2001). Validity and reliability for the Bruininks-Oseretsky Test of Motor Proficiency-Short Form as applied in the United Arab Emirates culture. *Perceptual and Motor Skills*; 92(1): 157-166.

Hattie J, & Edwards H. (1987). A Review of the Bruininks-Oseretsky Test of Motor Proficiency. *British Journal of Educational Psychology*; 57: 104-113.

Henderson S, & Sugden D. (1992). *The Movement Assessment Battery for Children*. The Psychological Corporation, Kent, UK.

Hernandez B, Gortmaker S, Colditz G, Peterson K, Laird N, & Para-Cabrera S. (1999). Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *International Journal of Obesity*; 23: 845–54.

Hill L, Williams JH, Aucott L, Milne J, Thomson J, Greig J, Munro V, Mon-Williams M. (2010). Exercising attention within the classroom. *Developmental Medicine & Child Neurology*; 52(10):929-34.

Hills AP, King NA, Armstrong TP. (2007). The contribution of physical activity and sedentary behaviours to the growth and development of children and adolescents: Implications for overweight and obesity. *Sports Medicine*; 37 (6): 533-545.

Hills AP. (2009). It's time to be more serious about activating youngsters: Lessons for Childhood Obesity. *Journal of Exercise Science and Fitness*; 7 (2): S28-S33.

Hirschler V, Aranda C, Calcagno M, Maccalini G. & Jadzinsky M. (2005). Can waist circumference identify children with the metabolic syndrome? *Archives of Pediatrics and Adolescent Medicine*; 159:740-744.

Howley ET. (2001). Type of activity: resistance, aerobic and leisure versus occupational physical activity. *Medicine and Science in Sports and Exercise*; 33: 364–369.

Hughes R. (2004). A conceptual framework for intelligence-based public health nutrition workforce development. *Public Health Nutrition*; 6(6): 599-605.

Janssen I & LeBlanc AG. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity*; 7:40.

Johnson E, McInnes MM, & Shinogle JA. (2006). 'What is the economic cost of overweight children?' *Eastern Economic Journal*; 32(1):171–87.

Jolliffe J, Taylor R, & Ebrihaim S. (2000). *A report on the clinical and cost effectiveness of physiotherapy in cardiac rehabilitation*. London: Chartered Society of Physiotherapy.

Kambas A, & Aggeloussis N. (2006). Construct validity of the Bruininks-Oseretsky Test of Motor Proficiency-short form for a sample of Greek preschool and primary school children. *Perceptual and Motor Skills*; 102(1): 65-72.

Katzmarzyk P. (2004). Waist circumference percentiles for Canadian youth 11–18 y of age. *European Journal of Clinical Nutrition*; 58:1011-1015.

Katzmarzyk P, Srinivasan S, Wei C, Malina R, Bouchard C, & Berenson G. (2004). Body mass index, waist circumference, and clustering of cardiovascular disease risk factors in a biracial sample of children and adolescents. *Pediatrics*; 114:E198–E205.

Kelishadi R, Gheiratmand R, Ardalan G, Adeli K, Mehdi G, Mohammad R, Majdzadeh R, Delavari A, Shariatinejad K, Motaghian M, Heshmat R, Heidarzadeh A, Barekati H,

Sadat Mahmoud-Arabi M, & Mehdi R, (CASPIAN Study Group) (2007). Association of anthropometric indices with cardiovascular disease risk factors among children and adolescents: CASPIAN Study. *International Journal of Cardiology*; 117:340-348.

Ketelhut K, Mohasseb I, Scheffler C, & Ketelhut R. (2004). Regular Exercise Improves Risk Profile and Motor Development in Early Childhood. *Journal of the American College of Cardiology*; 43(5), Supplement 2, 3, 523. Abstract.

Ketelaar M, Vermeer A, Hart H, Petegem-van Beek E, & Helders P. (2001). Effects of a Functional Therapy Program on Motor Abilities of Children with Cerebral Palsy. *Physical Therapy*; 81. (9).

Kirkcaldy B, Shephard R, Siefen R. (2002). The relationship between physical activity and self-image and problem behaviour among adolescents. *Soc. Psychiatry Psychiatr Epidemiol*; 37(11): 544-550.

Kodama S, Saito K, Tanaka S, Maki M, Yachi Y, Asumi M, Sugawara A, Totsuka K, Shimao H, Ohashia Y, Yamada N & Sone H. (2009). Cardiorespiratory fitness as a quantitative predictor of all-cause mortality and cardiovascular events in health men and women: A meta-analysis. *Journal of American Medical Association*; 301(19): 2024-2035.

Kraemer HC. (1992). *Evaluating medical tests: Objective and quantitative guidelines*. Newbury Park, CA: Sage.

Kroes M, Vissers YLJ, Sleijpen FAM, Feron FJM, Kessels AGH, Bakker E, Kalff AC, Hendriksen JGM, Troost J, Jolles J, Vles JSH. (2004). Reliability and validity of a qualitative and quantitative motor test for 5-6 year-old children. *European Journal of Paediatric Neurology*; 8:135-143.

Kropski JA, Keckley PH, Jensen GL (2008). School-based obesity prevention programs: an evidence-based review. *Obesity*; 16:1009–18.

Lake A, & Townshend T. (2006) Obesogenic environments: exploring the built and food environments. *The Journal of the Royal Society for the Promotion of Health*; 126(6): 262 - 268.

Lean M, Han T, & Morrison C. (1995). Waist circumference as a measure for indicating need for weight management. *British Medical Journal*; 311:158-161.

Lee I, & Skerrett P. (2001). Physical activity and all-cause mortality: what is the dose-response relation? *Medicine and Science in Sports and Exercise*; 33(6): S459-S471.

Lee YS. (2009). Consequences of childhood obesity. *Annals Academy of Medicine Singapore*; 38(1):75-7.

Leger L, & Lambert J. (1982). A maximal 20m shuttle run test to predict VO₂max. *European Journal of Applied Physiology*; 49(1): 1-12.

Leger LA, Mercier D, Gadoury C, Lambert J. (1998). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*; 6: 93-101.

Livingstone MB, Robson PJ, Wallace JM, & McKinley MC. (2003). How active are we? Levels of routine physical activity in children and adults. *Proceedings of the Nutrition Society*; 62 (3): 681-701

Lobstein T, Baur L, Uauy R. (2004). Obesity in children and young people: a crisis in public health. *Obesity Reviews*; 5 Suppl 1:4–104.

Luttikhuis H, Baur L, Jansen H, Shrewsbury V, O'Malley C, Stolk R, Summerbell C. (2009). Interventions for treating obesity in children. *Cochrane Database of Systematic Reviews*; Issue 1. Art. No.: CD001872. DOI: 10.1002/14651858.CD001872.pub2.

Mackinnon A. (2000). A spreadsheet for the calculation of comprehensive statistics for the assessment of diagnostic tests and inter-rater agreement. *Computers in Biology and Medicine*; 30(3): 127-134.

Maffeis C, Schena F, Zaffanello M, Zoccante L, Schutz Y, & Pinelli L. (1994). Maximal aerobic power during running and cycling in obese and non-obese children. *Acta Paediatrica*; 83: 113e16.

Maffeis C, Pietrobelli A, Grezzani A, Provera S, & Tato L. (2001). Waist circumference and cardiovascular risk factors in prepubertal children. *Obesity Research*; 9:179-187.

Magarey AM, Daniels LA, & Boulton T. (2001). Prevalence of overweight and obesity in Australian children and adolescents: reassessment of 1985 and 1995 data against new standard international definitions. *Medical Journal of Australia*; 174: 561-564.

Magarey A, Daniels L, Boulton T, & Cockington, R. (2003). Predicting obesity in early adulthood from childhood and parental obesity. *International Journal of Obesity*; 27, 505–513.

Mallory GB, Fiser DH & Jackson R. (1989). Sleep-associated breathing disorders in morbidly obese children and adolescents. *Journal of Pediatrics*; 115:892-7.

Marcus CL, Curtis S, Koerner CB, Joffe A, Servint JR & Lughlin GM. (1996). Evaluation of pulmonary function and polysomnography in obese children and adolescents. *Pediatric Pulmonology*; 21:176-83.

Martin A, Saunders DH, Shenkin SD, Sproule J. (2014). Lifestyle intervention for improving school achievement in overweight or obese children and adolescents. *Cochrane Database of Systematic Reviews*; Issue 3. Art No: CD009728. DOI: 10.1002/14651858.CD009728.pub2.

Matsuzaka A, Takahashi Y, Yamazoe M, Kumakura, N, Ikeda A, Wilk B, & Bar-Or O. (2004). Validity of the multistage 20-m shuttle-run test for Japanese children, adolescents, and adults. *Pediatric Exercise Science*; 16:113–125.

Mayor S. (2004). Government task force needed to tackle obesity. *British Medical Journal*; 328:363.

McAuley PA, Kokkinos PF, Oliveira RB, Emerson, BT & Myers JN. (2010). Obesity Paradox and Cardiorespiratory Fitness in 12,417 Male Veterans Aged 40 to 70 years. *Mayo Clinic Proceedings*; 85(2):115-121.

McCarthy H, Jarrett K, & Crawley H. (2001). The development of waist circumference percentiles in British children aged 5.0–16.9 y. *European Journal of Clinical Nutrition*; 55:902-907.

McGill H, McMahan C, Zieske A, Malcom G, Tracy R, Strong J. (2001). Effect of nonlipid risk factors on atherosclerosis in youth with favorable lipoprotein profile. Pathobiological Determinants of Atherosclerosis in Youth (PDAY) Research Group. *Circulation*; 103(11):1546–1550.

McGill H, McMahan C, Malcolm G, Oalman M, & Strong J. (1997). Effects of serum lipoproteins and smoking on atherosclerosis in young men and women. The PDAY Research Group. Pathobiological Determinants of Atherosclerosis in Youth. *Arteriosclerosis, Thrombosis, and Vascular Biology*; 17(1):95–106.

McVeigh SK, Payne AC, & Scott S. (1995). The reliability and validity of the 20-Meter Shuttle Test as a predictor of peak oxygen uptake in Edinburgh School Children, age 13 to 14 years. *Pediatric Exercise Science*; 17(1): 69–79.

Meisels SJ. (1988). Developmental screening in early childhood: The interaction of research and social policy. *Annual Review Public Health*; 9: 527-50.

Meyer A, Kundt G, Lenschow U, Schuff-Werner P, Kienast W. (2006). Improvement of Early Vascular Changes and Cardiovascular Risk Factors in Obese Children After a Six-Month Exercise Program. *Journal of the American College of Cardiology*; 48, (9).

Milne N, & Hing W. (2015). Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children. *Journal of Australian Strength and Conditioning*. In press.

Milne N, Low Choy N, Leong GM, Hughes R, & Hing W. (2015). Child Obesity service provision: a cross sectional survey of physiotherapy practice trends and professional needs. *Australian Journal of Primary Health*. In Press.

Milne N, Simmonds MJ & Hing W. (2014). *Modified Shuttle Test-Paeds: a valid cardiorespiratory fitness measure for children*. Unpublished. Chapter 6 PhD Thesis.

Mohr P, Wilson C, Dunn K, Brindal E, & Wittert G. (2007). Personal and lifestyle characteristics predictive of the consumption of fast foods in Australia. *Public Health Nutrition*; 10 (12), 1456–1463.

Moreno L, Fleta J, Mur L, Rodriquez G, Sarria A, & Bueno M. (1999). Waist circumference values in Spanish children–gender related differences. *European Journal of Clinical Nutrition*; 53:429-433.

Morrison J, Aronson Friedman L, Wang P, & Glueck C. (2008). Metabolic Syndrome in Childhood Predicts Adult Metabolic Syndrome and Type 2 Diabetes Mellitus 25 to 30 Years Later. *Journal of Pediatrics*; 152:201-6.

National Health and Medical Research Council – NHMRC (2003). *Clinical Practice Guidelines for the Management of Overweight and Obesity in Children and Adolescents*, Canberra, Commonwealth of Australia.

National Health and Medical Research Council – NHMRC (2013). *Clinical practice guidelines for the management of overweight and obesity in adults, adolescents and children in Australia*. Department of Health and Aging, Commonwealth of Australia.

National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents. (1996). Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program. *Pediatrics*; 98(4, pt 1):649-658.

National Preventative Health Taskforce. (2008). *Obesity Working Group Technical Report no 1. Obesity in Australia: a need for urgent action*. Updated in February 2009. Canberra. Available from: <http://www.preventativehealth.org.au/internet/preventativehealth/publishing.nsf/Content/tech-obesity>.

Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, Mullany E et al. (2014). Global, regional and national prevalence of overweight and obesity in children and adults during 1980 – 2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*; 384:766-81.

Oakley AD, & Booth ML. (2000). Relationship of enjoyment of physical activity and preferred activities to fundamental movement skills in young children. *International Journal of Behavioural Medicine* 7:S151.

Oakley A, Booth M & Chey T. (2004). Relationships between body composition and fundamental movement skills among children and adolescents. *Research Quarterly for Exercise and Sport*; 75(3): 238-47.

Oakley A, Booth M, Hardy L, Dobbins T, & Denney-Wilson E. (2008). Changes in physical activity participation from 1985 to 2004 in a state-wide survey of Australian adolescents. *Archives of Pediatrics and Adolescent Medicine*; 162(2):179–80.

Parsons T, Power C, Logan S, & Summerbell CD. (1999). Childhood predictors of adult obesity: a systematic review. *International Journal of Obesity*; 23: supplement 8, pp. S1–107.

Patterson P, Wiksten D, Ray L, Flanders C, & Sanphy D. (1996). The validity and reliability of the back saver sit and reach test in middle school girls and boys. *Research Quarterly for Exercise and Sport*; 67:448–51.

Peerlings W. (2007). *Bruininks-Oseretsky Test of Motor Proficiency*. 2nd edition. (BOT-2). In *Actuele Themata uit de psychomotorische therapie*, Johan Simons (ed.). Acco, Leuven/Leusden.

Pereira M, Kartashov A, Ebbeling C, Van Horn L, Slattery M, Jacobs D, & Ludwig D. (2005). Fast-food habits, weight gain, and insulin resistance (the CARDIA study): 15-year prospective analysis. *Lancet*; 365: 36–42

Piek JP, Baynam GB, & Barrett NC. (2006). The relationship between fine and gross motor ability, self-perception and self-worth in children and adolescents. *Human Movement Science*; 25(1): 65–75.

Pitetti KH, Fernhall B, Figoni S. (2002). Comparing two regression formulas that predict VO_2peak using the 20-m shuttle run for children and adolescents. *Pediatric Exercise Science*; 14:125–134.

Petrolini N, Lughetti L, & Bernasconi S. (1995). Difficulty in visual motor coordination as a possible cause of sedentary behaviour in obese children. *International Journal of Obesity Related Metabolic Disorders*.; 19:928.

Pope R, Herbert R, Kirwan JD, & Graham BJ. (1999). Predicting Attrition in Basic Military Training. *Military Medicine*; 164(10): 710-714.

Poustie V, Smyth R, & Cole T. (2005). Reliability of calculating body mass index centile. *European Journal of Clinical Nutrition*; 59: 717–719.

Powell KE, Casperson C, Koplan JP, & Ford ES. (1998) Physical activity and chronic disease. *American Journal of Clinical Nutrition*; 49: 999–1006.

Power C, Lake J, & Cole T. (1997). Measurements and long-term health risks of child and adolescent fatness. *International Journal of Obesity Related Metabolic Disorders*; 21(7): 507–520.

Queensland Government (2008). Toward Q2: Tomorrow's Queensland.

Redline S & Stroghl KP. (1999). Recognition and consequences of obstructive sleep apnea hypopnea syndrome. *Otolaryngologic Clinics of North America*; 32:303-31.

Reilly J, Armstrong J, Dorosty A, Emmett P, Ness A, Rogers I, Steer C, & Sherriff A. (2005). Early life risk factors for obesity in childhood: cohort study for the Avon Longitudinal Study of Parents and Children Study Team. *British Medical Journal*; doi:10.1136/bmj.38470.670903.E0 (published 20th May, 2005)

Rhodes SK, Shimoda KC, Waid LR, Mahlen P, Oexmann MJ, Collop NA, et al. (1995). Neurocognitive deficits in morbidly obese children with obstructive sleep apnoea. *Journal of Pediatrics*; 127:741-4.

Rogers DM, Olson BL, Wilmore JH. (1995). Scaling for the VO₂-to-body size relationship among children and adults. *Journal of Applied Physiology*; 79(3): 958 – 67.

Rokholm B, Baker JL, & Sorensen, TIA. (2010). The levelling off of the obesity epidemic since the year 1999 – a review of evidence and perspectives. *Obesity Reviews*; 11:835-846.

Rolland-Cachera MF. (2011). Childhood obesity: current definitions and recommendations for their use. *International Journal of Pediatric Obesity*; 6: 325–331.

Roman IR, Molinuevo JS, Quintana MS. (2009). The relationship between exercise intensity and performance in drills aimed at improving the proficiency, technical and tactical skills of basketball players. *International Journal of Sport Science*; 5(14): 1-10.

Sacher PM, Kolotourou M, Chadwick PM, Cole TJ, Lawson MS, Lucas A, Singhal A. (2010). Randomized controlled trial of the MEND program: A family-based community intervention for childhood obesity. *Obesity*; 18 (1).

Salmon J, Campbell K, & Crawford D. (2006). Television viewing habits associated with obesity risk factors: a survey of Melbourne schoolchildren. *Medical Journal of Australia*; 184 (2): 64-67.

Sartorio S, Del Col A, Agosti F, Mazzilli G, Bellentani S, Tiribelli C, & Bedogni G. (2007) Predictors of non-alcoholic fatty liver disease in obese children. *European Journal of Clinical Nutrition*; 61: 877–883.

Savva S, Kourides Y, Tornaritis M, Epiphaniou-Savva M, Tafouna P, Kafatos A. (2001). Reference growth curves for Cypriot children 6 to 17 years of age. *Obesity Research*; 9:754-762.

Schoemaker M, Hijlkema M, & Kalverboer A. (1994). Physiotherapy for Clumsy children: an evaluation study. *Developmental Medicine & Child Neurology*; 36(2), 143–155.

Schwartz M, & Puhl R. (2003). Childhood obesity: a societal problem to solve. *Obesity Reviews*; 4: 57–71.

Schwimmer J, Burwinkle T, & Varni J. (2003). Health-Related Quality of Life of Severely Obese Children and Adolescents. *Journal of American Medical Association*; 289(14).

Shultz S, Deforche B, Byrne N, Hills A. (2011). *Global Perspectives on Childhood Obesity Chapter 34 - Fitness and Fatness in Childhood Obesity: Implications for Physical Activity*. Advanced web-based viewing. Elsevier. Accessed 18th December, 2010.

Silventoinen K, Rokholm B, Kaprio J, & Sørensen T. (2010). 'The genetic and environmental influences on childhood obesity: a systematic review of twin and adoption studies'. *International Journal of Obesity*; 34, (1) 29–40.

Silvesti JM, Weese-Mayer DE, Bass MT, Kenny AS, Hauptmann SA, Pearsall SM. (1993). Polysomnography in obese children with history of sleep associated breathing disorders. *Pediatric Pulmonology*; 16:124-9.

Smyth M, & Anderson H. (2000). Coping with clumsiness in the school playground: social and physical play in children with coordination impairments. *British Journal of Developmental Psychology*; 18: 389–413.

Southall J, Okely A, & Steele J. (2004). Actual and perceived competence in overweight and non-overweight children. *Pediatric Exercise Science*; 16:15e24.

Stodden DF, Goodway JD, Langendorfer SJ, Robertson MA, Rudisill ME, Garcia C & Garcia LE. (2008). A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest*; 60:2, 290-306.

Strong WB, Malina RM, Blimkie CJR, Daniels SR, Dishman RK, Gutin B, et al. (2005). Evidence based physical activity for school-age youth. *Journal of Paediatrics*; 146: 732-7.

Sugerman HG, DeMaia EJ, Felton WL, Nakatsuka M & Sismanis A. (1997). Increased intra-abdominal pressure and cardiac filling pressure in obesity associated pseudotumor cerebri. *Neurology*; 49:507-11.

Summerbell C, Waters E, Edmunds L, Kelly S, Brown T, & Campbell K. (2009) Interventions for preventing obesity in children. *Cochrane Database of Systematic Reviews*; Issue 3. Art. No.: CD001871. DOI: 0.1002/14651858.CD001871.pub2.

Sung R, Yu C, Choi K, McManus A, Li A, Xu S, Chan D, Lo A, Chan J, Fok T. (2007). Waist circumference and body mass index in Chinese children: cut-off values for predicting cardiovascular risk factors. *International Journal of Obesity*, 31:550-558.

Swallen K, Reither E, Haas S, & Meier A. (2005). Overweight, Obesity, and Health-Related Quality of Life Among Adolescents: The National Longitudinal Study of Adolescent Health. *Pediatrics*; 115; 340-347.

Swets JA. (1988). Measuring the accuracy of diagnostic systems. *Science*; 240: 1285–1293.

Swinburn B, Caterson I, Seidell J, & James W. (2004). Diet, nutrition and the prevention of excess weight gain and obesity. *Public Health Nutrition*; 7:123– 46.

Taras H, & Potts-Datema W. (2005). Obesity and Student Performance at School. *Journal of School Health*; 75:291-295.

Telford RD, Cunningham RB, Telford RM, Abhayaratna WP. (2012). Schools with fitter children achieve better literacy and numeracy results: evidence of a school cultural effect. *Pediatric Exercise Science*; 24(4):ii.

The Cooper Institute for Aerobics Research. (1997). The Physical Fitness Specialist Certification Manual. Dallas TX; cited in Heyward, VH. *Advance Fitness Assessment and Exercise Prescription*, 3rd Edition; 1998. p 48.

Thompson G, & Carter J. (1990). Late-onset tibia vara (Blount's disease). Current concepts. *Clinical Orthopaedics and Related Research*; 255:24-35.

Thorne JC, Coggins TE, Olson HC & Astley SJ. (2007). Exploring the utility of narrative analysis in diagnostic decision making: picture-bound reference, elaboration, and fetal alcohol spectrum disorders. *Journal of Speech, Language, and Hearing Research*; 50: 459-474.

Tomkinson GR, Leger LA, Olds TS, Cazorla G. (2003). Secular Trends in the Performance of Children and Adolescents (1980 – 2000). *Sports Medicine*; 33 (4): 285 – 300.

Tomprowski PD, Davis CL, Miller PH, Naglieri JA. (2008). Exercise and children's intelligence, cognition, and academic achievement. *Educational Psychology Review*; 20(2): 111–131.

Tsiros MD, Buckley JD, Howe PRC, Olds T, Walkley J, Taylor L, Mallows R, Hills AP, Kagawa M, Coates AM. (2012). Day-to-day physical functioning and disability in obese 10- to 13-year-olds. *Paediatric Obesity*; 8(1): 31-41.

Tsiros MD, Coates AM, Howe PRC, Grimshaw PN, Walkley J, Shield A, Mallows R, Hills AP, Kagawa M, Shultz S, Buckley JD. (2013). Knee extensor strength differences in obese and healthy-weight 10-to 13-year-olds. *European Journal of Applied Physiology*; 113:1415-1422.

Tsiros MD, Coates AM, Howe PRC, Grimshaw PN, Buckley, JD. (2011). Obesity: the new childhood disability? *Obesity Reviews*; 12 (1): 26-36.

Tsiros MD, Olds T, Buckley JD, Grimshaw P, Brennan L, Walkley J, Hills AP, Howe PRC, Coates AM (2009). Health-related quality of life in obese children and adolescents. *International Journal of Obesity*; 33:387–400.

Twisk JW, Kemper HC, van Mechelen W. (2002). The relationship between physical fitness and physical activity during adolescence and cardiovascular disease risk factors at adult age. The Amsterdam Growth and Health Longitudinal Study. *International Journal of Sports Medicine*; 23(S1): 8–14.

Ulrich D, Lloyd M, Tiernan C, Looper J, & Angulo-Barroso R. (2008). Effects of Intensity of Treadmill Training on Developmental Outcomes and Stepping in Infants With Down Syndrome: A Randomized Trial. *Physical Therapy*; 88 (1).

U.S. Department of Health and Human Services. (1996). *Physical Activity and Health: A Report of the Surgeon General*. Atlanta, GA; U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion.

Varness T, Carrel A, Eickhoff J, & Allen D. (2009) Reliable Prediction of Insulin Resistance by a School-Based Fitness Test in Middle-School Children International *Journal of Pediatric Endocrinology*; Vol 2009: Article ID 487804, 7 p.

Washington RL, Bricker JT, Alpert BS, Daniels SR, Deckelbaum RT, Fisher EA, Gidding SS, Isabel-Jones J, Kavey RE, Marx GR, et al. (1994). Guidelines for exercise testing in the pediatric age group. From the Committee on Atherosclerosis and Hypertension in Children, Council on Cardiovascular Disease in the Young, the American Heart Association. *Circulation*; 90: 2166-2179.

Wasserman K, Hansen JE, Sue DY, Whipp BJ, & Casaburri R. (1994). *Principles of exercise testing and interpretation*. 2nd ed. Philadelphia: Williams and Wilkins; p.27-30.

Waters E, de Silva-Sanigorski A, Burford BJ, Brown T, Campbell KJ, Gao Y, Armstrong R, Prosser L, Summerbell CD. (2011). *Cochrane Database of Systematic Reviews*; Issue 12. Art. No.: CD001871. DOI: 10.1002/14651858.CD001871.pub3.

Wattigney R, (1998). Association between multiple cardiovascular risk factors and the early development of atherosclerosis. Bogalusa Heart Study. *New England Journal of Medicine*; 338(23):1650–1656.

Wedderkopp N, Froberg K, Hansen HS, Andersen, LB. (2004). Secular trends in physical fitness and obesity in Danish 9-year-old girls and boys: Odense School Child Study and Danish substudy of the European Youth Heart Study. *Scandinavian Journal of Medicine and Science in Sports*; 14 (3); 150–155.

WHO (1998). Obesity: Preventing and managing the global epidemic. *Report of a WHO consultation on obesity*. World Health Organization: Geneva.

WHO (2000). *Obesity: Preventing and Managing the Global Epidemic*, Report of a WHO consultation, WHO technical report series no. 894, Geneva.

Whitaker R. (2004). Predicting Preschooler Obesity at Birth: The Role of Maternal Obesity in Early Pregnancy. *Pediatrics*; 114; e29-e36.

Woo K, Chook P, Yu C, Sung R, Qiao M, Leung S, Lam C, Metreweli C, & Celermajer D. (2004). Effects of Diet and Exercise on Obesity-Related Vascular Dysfunction in Children. *Circulation*; 109: 1981-1986.

World Confederation of Physical Therapy (WCPT). *Obesity*. Available at: <http://www.wcpt.org/node/33341#facts> (Verified 21st March, 2013)

Wrotniak B, Epstein L, Dorn J, Jones K, & Kondilis V. (2006). The relationship between motor proficiency and physical activity in children. *Pediatrics*; 118(6):1758-1765.

Yassine H, Marchetti C, Krishnan R, Vrobel T, Gonzalez F, & Kirwan J. (2009). Effects of Exercise and Caloric Restriction on Insulin Resistance and Cardiometabolic Risk Factors in Older Obese Adults-A Randomized Clinical Trial. *The Journals of Gerontology: Series A Biological sciences and medical sciences*; 64A(1), 90-5.

Zannolli R, & Morgese G. (1996). Waist percentiles: a simple test for atherogenic disease? *Acta Paediatrica*; 85:1368-1369.

Zhang J, Zhang D, & Chen L. (2004). Validity and reliability of the Wood Motor Success Screening Tool in a special physical education learning laboratory. *Perceptual & Motor Skills*; 99(3 Pt 2): 1251-1256.

Zimmit P. (2003). Diabetes in Australia: An affair of the heart. *Heart Lung and Circulation*; 12, SUPPL. 2. S95-S98.

CHAPTER 11.

APPENDICES

Appendix 1 – Student Database

Appendix 2 – Data Collection Sheet

Appendix 3 – Poster: ANZOS Annual Scientific Meeting, 2010

Appendix 4 – Poster: ANZOS Annual Scientific Meeting, 2014

Appendix 5 – Poster: Gold Coast Health and Medical Research Conference, 2014

Appendix 6 - Explanatory Statement / Consent – Inter-tester Reliability (Child)

Appendix 7 - Explanatory Statement / Consent – Inter-tester Reliability (Examiner)

Appendix 8 - Explanatory Statement / Consent – Parent and Participant (RO1019)

Appendix 9 – Recruitment Flyer (RO1019)

Appendix 10 – BUHREC Ethical Approval (RO1019)

Appendix 11 – Explanatory Statement Consent (RO1144)

Appendix 12 – Paper copy of survey (RO1144)

Appendix 13 – BUHREC Ethical Approval (RO1144)

Appendix 14 – Explanatory Statement / Consent (RO1601)

Appendix 15 – Bond University Ethical Approval (RO1601)

Appendix 1 – Student Database



Student Database

To be completed by Parent

Child's Name:	Date of Birth:
School:	Year Level:
Gender: Male <input type="checkbox"/> Female <input type="checkbox"/>	
Medical Conditions / Diagnosis:	
Consent to be contacted for offer to participate in future child health related studies by the research team: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Address:	Home Ph: Mobile Ph:
E-mail:	
Comments:	

Completed by: (name) _____

Relationship to child: Mother ☐ Father ☐ Other (please state) _____

Signature: _____ Date: _____

Appendix 2 – Data Collection Sheet



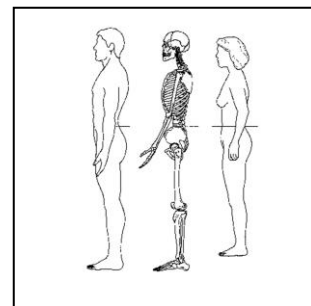
Data Collection Sheet

Name:		Test Date	Year	Month	Day
Year Level:		DOB			
School:		Chron. Age			
Waist Circumference (cm): Iliac Crest x 2 measures		Waist Circumference (cm): Umbilicus x 2 measures			
Height (cm):		Weight (kg):			
BMI: Weight(kg) / Height (m2)		BP Pre-test: / mmHg			
		HR Pre-test: b/min			
Sit and Reach Test (cm): x 2 trials		Upper Limb Flexibility Test (degrees): x 2 trials			
Balance Test SLS EO (Sec): Dominant Leg		SAMS (Sec): x 2 trials			
Balance Test SLS EC (Sec): Dominant Leg					
BOT2 Subtest	BOT2 %ile Rank	BOT2 Descriptive Category	Comments (Task Related)		
Fine Motor Precision			Compliant <input type="checkbox"/>		
Fine Motor Integration			Non-compliant <input type="checkbox"/>		
Fine Manual Control			Upright Posture <input type="checkbox"/>		
Manual Dexterity			Slumped Posture <input type="checkbox"/>		
Upper-Limb Coordination			Good Comprehension <input type="checkbox"/>		
Manual Coordination			Poor Comprehension <input type="checkbox"/>		
Bilateral Coordination			Other: <input type="checkbox"/>		
Balance					
Body Coordination					
Running Speed and Agility					
Strength					
Strength and Agility					
TOTAL MOTOR COMPOSITE					
Modified Shuttle Test Paeds (1 min) – 10 metre track (no. of bean bags in tray – give ½ mark if collected a bean bag but has not reached the tray):		BP Post-test: / mmHg			
		HR Post-test: b/min			
Tester Name:					

Instructions for Data Collection Methods

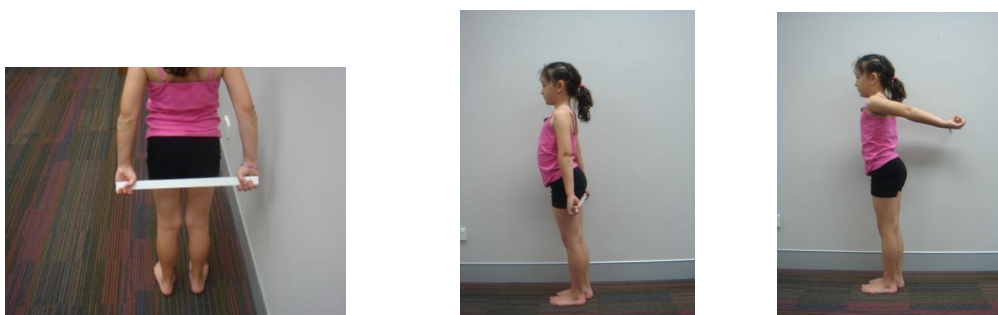
Waist Circumference: (2 x measures at IC and 2 x measures at the umbilicus)

1. Have student in a standing position with arms by side.
2. Have another person hold up their shirt (or tie shirt with an elastic band) so that the tape measure is against the skin
3. Position the tape measure horizontally in line with the top of the iliac crest
4. Ask the student to "relax and breathe out"
5. Read and record the measurement at the end of expiration.
6. Repeat the measure with the tape in horizontal line to the umbilicus



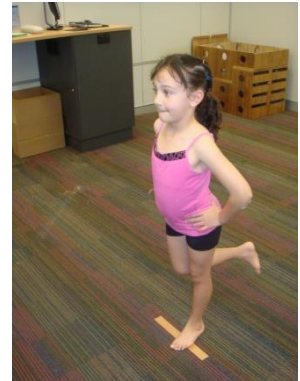
Upper Limb Flexibility Test: (1 x trial and 1x measure)

1. Ask the student to stand against the wall with shoulder and hip against the vertical line.
2. Ask the student to hold the rod (with lateral border of the hands placed on the outside borders of the rod, knuckles facing down) behind their bottom.
3. Ask the student to lift the rod as high as they can behind their back (keeping their elbows straight and keeping body in line with vertical line on wall. i.e. not leaning forward)
4. Measure the angle between top of shoulder to top of elbow and the vertical of the trunk using the angle finder supplied.



Balance Test SLS EO: (1 x trial and 1x test)

1. Establish the dominant balance leg (this is the opposite leg to which the student will kick a ball)
2. Ask the student to stand 2 metres away from the wall directly facing the circle on their dominant balance leg, with hands on hips and knee flexed at approximately 90 degrees for as long as they can.
3. Encourage the student to place foot on ground before allowing them to fall.
4. Start timing as the student lifts the foot off the ground
5. Stop timing when the student touches the ground with the lifted leg and or takes hands off hips.
6. Stop timing at 1 minute maximum.



Balance Test SLS EC: (1 x trial and 1 x test)

1. Repeat the test above only ask the student to close their eyes as soon as they establish SLS.
2. Start timing when the student closes their eyes.
3. Record the time that the student either touches the ground with the lifted leg, takes hands off hips or opens eyes.
4. Stop timing at 1 minute maximum.



Speed and Agility Motor Screen (SAMS): (2 x trials and 2 x timed test)

1. Ask the student to stand at the end (to the left) of a 3 metre line (as measured on the ground) facing 90 degrees away from the line.
2. Start position – standing upright with hands by side, move to lying on stomach with hands straight above head and feet together, roll 360 degrees (to the right) back to stomach, move to standing on feet and jump feet apart and then feet together (like a two stage star jump).
3. Start timing on the instruction “ Ready Go”
4. Stop timing when the students’ feet touch the ground as they come back together.

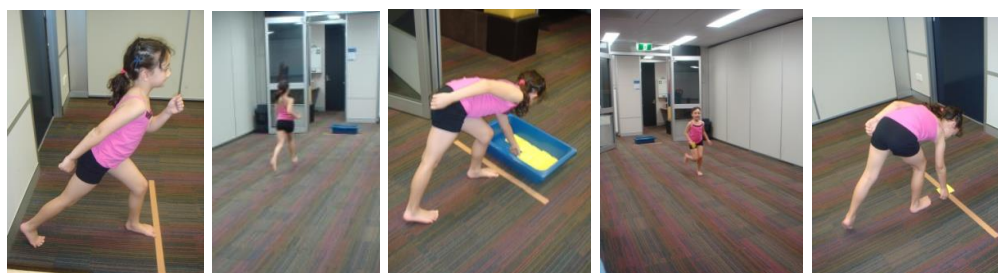


Modified Shuttle Test - Paeds:

1. Place 2 x 1 metre strips of tape on floor 10 metres apart



2. Start position – standing with front foot touching the line
3. On “GO” I want you to run as fast as you can without falling over, pick up 1 bean bag from the tray and return it to the line at the other end by placing it on the line (not throwing it).
4. Repeat this as many times as you can in 3 minutes.
5. Record the number of bean bags on the line at the end of 3 minutes.





Validating the Speed and Agility Motor Screen (SAMS) as a motor performance-related fitness measure for children

Milne N¹, Hing W¹.

¹Physiotherapy, Faculty of Health Sciences and Medicine, Bond University.


Introduction

- To be physically active during childhood, children require the attributes of both health-related fitness (i.e. cardiorespiratory endurance) and performance-related fitness (i.e. motor proficiency; balance, coordination, speed and agility).
- Exercise capacity (which requires the combined attributes of health and performance-related fitness) decreases all-cause mortality⁴ independent of adiposity⁵.
- Motor proficiency significantly impacts the likelihood of participation in physical activity⁶, overall performance on cardiovascular fitness (CRF) tests^{3,1} and the extent of excessive weight and obesity².
- There are potential health benefits to be gained through development of paediatric-specific motor screening measures that can identify children who have reduced motor proficiency which may be associated with, or an underlying cause of, reduced CRF or obesity.
- The Speed and Agility Motor Screen (SAMS) has been specifically designed for this purpose.

Purpose

This study aimed to: 1) assess the test-retest reliability and concurrent-validity of the Speed and Agility Motor Screen (SAMS) and 2) establish a SAMS cut-off time to identify children who may benefit from further investigation of their gross motor skills.

Methods

- Ethical approval:** Bond University Human Research Ethics Committee (RO1019).
- Design:** A concurrent validity and test-retest reliability study was implemented with 233 school-aged children (n=M-120: F-113), aged 5-17 years (Mean±SD:11.44 ± 2.18yrs).
- Physical measures included:** Bruininks-Oseretsky-Test-of-Motor-Proficiency-2nd Edition (BOT2) and the SAMS (a timed measure as seen in photos below). A representative sample (n=77) also completed Body-Mass-Index (BMI) measurements (Mean ±SD: BMI percentile = 50.27 ± 30.86).
- Data Analysis:** Means, SD, t tests: Differences in BMI groups/gender. Test-retest reliability (ICC). Pearson's product moment correlations: SAMS and BOT2. Linear Regression: Contribution of BOT2 measures to SAMS completion time. Multiple regression: Examines the relationship between the SAMS and combinations of BOT2 gross motor skills



Relationship between the SAMS and Gross Motor Performance

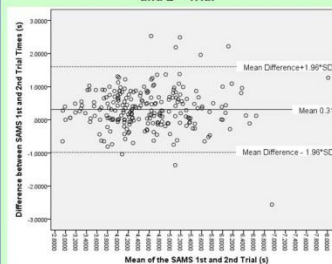
BOT2 Variables	Total Group		Participants Measured Anthropometrically	
	All Study Participants (n=233)	BMI Percentile < 85th (n=63)	BMI Percentile ≥ 85th (n=14)	
	r	r ²	r	r ²
Bilateral Coordination	-.167** (.011)	.028* (.011)	-.183 (.151)	.033 (.151)
Balance	-.398** (.000)	.158** (.000)	-.296* (.018)	.088* (.003)
Running Speed & Agility	-.478** (.000)	.229* (.000)	-.444** (.000)	.197** (.006)
Strength	-.433** (.000)	.187 (.000)	-.402** (.001)	.162** (.002)
Combined Gross Motor Skills	-.463** (.000)	.214** (.000)	-.409** (.001)	.167** (.002)

- The SAMS had low-to-moderate predictive validity for determining gross-motor ability in the general population of children ($r^2=0.214$, $p<0.001$) but a strong predictive-validity with overweight/obese children ($r^2=0.641$, $p=0.001$).
- Children who took ≥5.43s to complete the SAMS had significantly lower motor proficiency than children who took <5.43s ($t = 6.145$, $DF=225$, $p<0.001$).

Results

- The SAMS was found to have strong test-retest reliability (ICC=0.87, 95% CI: 0.710, 0.816).

Figure 1. 95% Limits of Agreement for the SAMS 1st and 2nd Trial



- The motor components of balance (15.8%), bilateral-coordination (2.8%), strength (18.7%), running-speed and agility (22.9%) were all significant contributors to the SAMS completion time.

The Speeds and Agility Motor Screen (SAMS) is a timed measure that requires the child to move from standing with hands by side, to laying prone with hands above head and feet together, then rolling as a log 360 degrees, standing up and performing a jumping jack (2-stage star jump) as fast as they can.

Discussion

- The SAMS is a quick to administer test that was designed to be used in conjunction with health-related fitness measures, by those who work with children (e.g. Coaches, Health-Physical-Education Teachers, Health-Professionals). The SAMS should be used when concerns exist regarding motor proficiency as a possible contributor to poor health and fitness and to guide referral decisions.

Conclusions

- The SAMS is a valid and reliable screening measure that can be used to predict poor gross motor proficiency in overweight or obese children.

References

- Carney J, Hay JA, Faught BE, Florio A & Klenzou P. Developmental Coordination Disorder and Cardiorespiratory Fitness in Children. *Pediatric Exercise Science*. 19: 20-28. 2007.
- Faught BE, Hay JA, Carney J & Florio A. Increased risk for coronary vascular disease in children with developmental coordination disorder. *Journal of Adolescent Health*. 37: 375-380. 2005.
- Handis B & Larkin D. Physical Activity Measurement Methods for Young Children: A comparative study. *Measurement in Physical Education and Exercise Science*. 10 (3): 203-214. 2006.
- Lee I & Skerrett P. Physical activity and all-cause mortality: what is the dose-response relation? *Medicine and Science in Sports and Exercise*. 33(6): S469-S471. 2001.
- McAuley PA, Kalkreuth PF, Oliveira RB, Emerson BT & Myers JN. Obesity Paradox and Cardiorespiratory Fitness in 12,417 Male Veterans Aged 40 to 70 years. *Mayo Clinic Proceedings*. 85(2): 115-121. 2010.
- Smyth MM & Anderson H. Coping with clumsiness in the school playground: Social and physical play in children with coordination impairments. *British Journal of Developmental Psychology*. 18: 389-413. 2000.



Assistant Professor Nikki Milne – nmilne@bond.edu.au (07) 5595 4155



Explanatory Statement

Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children: reliability testing of the data collection tool.

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

This study aims to validate two simple measures of health, agility and fitness in children. The first simple measure - waist circumference (WC) - could be established as an indicator of health while the Milne Motor Test (MMT) could be indicative of motor skill, agility and fitness. Prior to completion of the larger part of this study the data collection tool must be found to be reliable. Thus the aim of this preliminary study is to:

Establish the inter and intra reliability of the data collection tool to be used in the larger study which investigates associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in South East Queensland children.

You are asked to give permission for the following measures to be collected with your children:

1. Height, Weight and BMI (Body Mass Index)
2. Waist circumference
3. BOT2 – complete test. This is an internationally recognized standardized measure of motor ability used for persons aged 4 years - 21 years.
4. The Milne Motor Test (incorporating functional strength, coordination, speed and agility) – this is a quick timed test that asks your child to move from

- standing with hands by side, to laying on their stomach with hands above head and feet together, then rolling as a log 360 degrees, standing up jumping hands and feet out and then in (2 stage star jump).
5. Sit and Reach Flexibility Test - your child will be asked to sit on the floor with legs straight and reach as towards / past toes as far as possible.
 6. Upper Limb Flexibility Test - your child will be asked to stand side-on against a wall while holding a batten between both hands behind their bottom. Your child will then lift the batten as high as he/she can with straight arms - the angle will be measured.
 7. Blood pressure (pre and post testing)
 8. Modified Shuttle test - this is a timed running test, where your child will be asked to run 10m, pick up a small hand held bean bag, run back and place it in a tray and to repeat this as many times as he/she can in 1 minute.
 9. Balance task – your child will be timed to a maximum of 30secs while standing on one leg (eyes open and eyes closed) with hands on hips.

These measures will take up to approximately 1 hour to complete and all measures will be completed in the Physiotherapy Clinical Skills room on level 1 in the Health Sciences and Medicine Building at Bond University. Four research assistants will be participating in the test sessions. All members of the research team have undergone a working with children check and are registered Teachers or Physiotherapists.

Participants of all shapes, sizes and fitness / motor skill levels are requested for this study. Unfortunately however, if your child has been formally diagnosed with a physical disability they will not be able to participate in the study.

It is anticipated that the data collected / results from this study will add to the field of knowledge in the area of childhood fitness, motor proficiency and obesity in the hope of developing a screening tool which can be used by physical education teachers and school health nurses for screening children for conditions relating to obesity, heart disease and type II diabetes.

The research team is seeking approximately 18 children aged 5 – 18 years to participate in this study on a weekend. Students will be given a database / questionnaire to be completed in advance by their parents / carers that will take approximately 15 minutes to complete. This information will help the researchers make links between age, gender, motor skills and parents perceived level of physical activity and health status of their child. It will also establish if parents are willing for their child to participate in future research opportunities in this area with the same research team. The authors of this study plan to complete post-doctoral longitudinal research looking at how waist circumference and the MMT might predict chronic health outcomes for children of varying ages and would therefore like to be able to follow up the same children.

No findings/ information, which could identify any individual participant, will be published. Content showing age related, gender related and geographical trends for the above mentioned data only will be published. The confidentiality of your child's participation results is assured by our procedure, in which the databases / questionnaires of all participants will be accessed only by the research team and the raw data will be stored in a locked cabinet in the Principal Researcher's office at Bond University until it is destroyed.

IMPORTANT NOTE: On the day of testing your child will need to be wearing a tee-shirt (with a crop-top underneath for girls), bike-pants or shorts (not culottes) on the lower half and joggers for footwear. A parent/carer is required to attend during the testing period for this study.

Nikki Milne
Assistant Professor of Physiotherapy and Chief Investigator

Or

Dr Nancy Low Choy Signature _____
Associate Professor of Physiotherapy and Principal Investigator/Supervisor,

Ph: (07) 5595 4449
Fax: (07) 5595 4480
E-mail: nlowchoy@bond.edu.au
Address: Faculty of Health Sciences and Medicine, Bond University Q 4229.

Should you have any complaints concerning the manner in which this research is conducted, please do not hesitate to contact Bond University Human Research Ethics Committee, quoting the Project Number (**RO-1019**):

The Complaints Officer
Bond University Human Research Ethics Committee
Bond University
Gold Coast, 4229.
Telephone (07) 5595 4194 Fax (07) 5595 1120
E-Mail buhrec@bond.edu.au

CONSENT FORM must be signed and returned with the completed DATABASE if you wish for your child to participate in this study.

PLEASE NOTE: You should keep this copy of the explanatory statement for your records



CONSENT FORM
(Inter-tester Reliability) Child

Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children: reliability testing of the data collection tool.

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

This study aims to validate two simple measures of health, agility and fitness in children. The first simple measure - waist circumference (WC) - could be established as an indicator of health while the Milne Motor Test (MMT) could be indicative of agility and fitness. Prior to completion of the larger part of this study the data collection tool must be found to be reliable. The specific aim of the study is to:

Establish the inter and intra reliability of the data collection tool to be used in the larger study which investigates associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children.

CONSENT: I, (parents name) _____ have read and understand the attached explanatory statement and have explained the study to my child and agree for my child (child's

name) _____ from (year level) _____, (school name) _____

to be included as a participant of this study by staff from Bond University.

Signature: _____ Date: _____

Child 's Signature: _____ Date: _____

Witness: _____ Date: _____



Explanatory Statement
(Inter-tester Reliability) Examiner

Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children: reliability testing of a data collection tool.

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

Prior to the completion of a larger study which aims to establish relationships between waist circumference, blood pressure, motor skills, fitness levels and BMI in South East Queensland children, a reliability study of the data collection tool must be completed. The specific aim of the study is to:

Establish the inter and intra reliability of the data collection tool to be used in the larger study which investigates associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children.

You are asked to give consent as a Physiotherapist or Physical Education Teacher and participate in collecting data from children aged 5 years – 18 years for the following measures:

1. Height, Weight and BMI (Body Mass Index)
2. Waist circumference
3. BOT2 – complete test. This is an internationally recognized standardized measure of motor proficiency used for persons aged 4 years - 21 years.
4. The Milne Motor Test (incorporating functional strength, coordination, speed and agility) – a quick timed test requesting the child moves from standing with hands by side, to laying on stomach with hands above head and feet together, then rolling as a log 360 degrees, standing up jumping hands and feet out and then in (2 stage star jump).
5. Sit and Reach Flexibility Test - Participant sits with legs straight and reaches as far towards / past toes as possible.

6. Upper Limb Flexibility Test - Standing side-on against a wall holding a batten between both hands (behind the buttocks). The participant is asked to lift the batten as high as he/she can with straight arms and the angle is measured.
7. Blood pressure (pre and post testing)
8. Modified Shuttle test - a timed running test, where the participant is asked to run 10m, pick up a small hand held bean bag, run back and place it in a tray and to repeat this as many times as he/she can in 1 minute.
9. Balance task – Standing on one leg (eyes open and eyes closed) with hands on hips.

These measures will take up to 1 hour to complete per child and all measures will be completed in the Physiotherapy Clinical Skills room on level 1 in the Health Sciences and Medicine Building at Bond University. Up to 18 children / adolescents will be participating in the test sessions. All research assistant participants must have undergone a working with children check and be registered Teachers or Physiotherapists.

It is anticipated that the data collected / results from this study will add to the field of knowledge in the area of childhood fitness, motor proficiency and obesity in the hope of developing a screening tool which can be used by physical education teachers and school health nurses for screening children for conditions relating to obesity, heart disease and type II diabetes.

The research team is seeking approximately four research assistants to participate in this study over 1 weekend. Up to 18 children will be trial participants in this study and data collected from their testing will be added to the pool of data collected from the larger study in which you will participate as a researcher. The children you will work with on this study will be given a database / questionnaire to be completed in advance by their parents / carers that will take approximately 15 minutes to complete. This information will help the researchers make links between age, gender, motor skills and parents perceived level of physical activity and health status of the child. It will also establish if parents are willing for their child to participate in future research opportunities in this area with the same research team. The authors of this study plan to complete post doctoral longitudinal research looking at how waist circumference and the MMT might predict chronic health outcomes for children of varying ages and would therefore like to be able to follow up the same children.

No findings/ information, which could identify any individual participant of this study, will be published. Content demonstrating inter and intra reliability of the data collection tool and content showing age and gender related trends for the data collected will be published. The confidentiality of your participation results is assured by our procedure, in which the findings of all participants will be accessed only by the research team and the raw data will be stored in a locked cabinet in the Principal Researcher's office at Bond University until it is destroyed.

The outcomes of the testing will not be made directly available to the children you will be testing; however should their parents wish to obtain their child's individual results they will be invited to contact the research investigators listed at the bottom of this document.

If you agree to participate in this study you may withdraw your consent at any time. Not participating in the research will not disadvantage you in any way, other than



CONSENT FORM
(Inter-tester Reliability) Examiner

Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children: reliability testing of the data collection tool.

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Dr Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

The specific aim of the study is to:

Establish the inter and intra reliability of the data collection tool to be used in the larger study which investigates associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children.

CONSENT: I, (name) have read and understand the attached explanatory statement and agree to be included as a participant of this reliability study being undertaken by staff from Bond University.

Signature: _____ Date: _____

Witness: _____ Date: _____



Explanatory Statement (Parent and Participant)

Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in Queensland children.

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Dr Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

The objective of this study is to validate two simple measures of health, agility and fitness in children. The first simple measure - waist circumference (WC) - could be established as an indicator of health while the Milne Motor Test (MMT) could be indicative of motor skill, agility and fitness.

The specific aims of the study are to:

1. Establish the validity of the MMT (Milne Motor Test) as a suitable test of motor ability for children aged 5 – 18 years.
2. Investigate associations between a number of health related measures in children aged 5 – 18 years from varying geographical regions of Queensland.
3. Establish early data for collation with larger studies which can be used to develop Queensland and Australian Waist Circumference percentiles.

For this reason, we are seeking children of all shapes, sizes and fitness levels from Queensland. We will ask you to complete a simple questionnaire (to be completed by parent / carer) to develop a student database including Age, DOB, Gender reported medical history, School, physical activity levels, description of child's health status & activity level. You will also be asked to supply your child's name and contact details if you are happy to be contacted with an offer to participate in future longitudinal studies by the same authors. The authors of this study plan to complete post-doctoral longitudinal research looking at how waist circumference and the MMT might predict chronic health outcomes for children of varying ages and would therefore like to be able to follow up the same children.

You are asked to give permission for the following measures to be collected with your children:

1. Height, Weight and BMI (Body Mass Index)
2. Waist circumference
3. BOT2 – complete test. This is an internationally recognized standardized measure of motor proficiency used for persons aged 4 years - 21 years.
4. The Milne Motor Test (incorporating functional strength, coordination, speed and agility) is a quick timed test that would require your child to move from standing with hands by side, to laying on the stomach with hands above head and feet together, then rolling as a log 360 degrees, standing up jumping hands and feet out and then in (2 stage star jump).
5. Sit and Reach Flexibility Test - your child will sit on the floor with legs straight and reach towards / past toes as far as possible.
6. Upper Limb Flexibility Test - your child will stand side-on against a wall holding a batten between both hands and behind their bottom. Your child will be asked to lift the batten as high as he/she can with straight arms - the angle is measured.
7. Blood pressure (pre and post testing)
8. The Modified Shuttle test is a timed running test, where your child will be asked to run 10m, pick up a small hand held bean bag, run back and place it in a tray and to repeat this as many times as he/she can in 1 minute.
9. Balance task – Your child will be asked to stand on one leg (eyes open and eyes closed) with hands on hips.

These measures will take approximately 1 hour to complete and all measures will be completed on the school grounds (either in the classroom, school hall, undercover area or school oval). In each school setting up to four research assistants will be participating in the test sessions, however at any one time only two testers would be present. All members of the research team have undergone a working with children check and are registered Teachers or Physiotherapists.

It is critical that this study attracts children of all shapes, sizes and fitness / motor skill levels in order to obtain the required data. Unfortunately however, if your child has been formally diagnosed with a physical disability they will not be able to participate in the study. It is anticipated that the data collected / results from this study will add to the field of knowledge in the area of childhood fitness, motor ability and obesity in the hope of developing a screening tool which can be used by physical education teachers and school health nurses for screening children for conditions relating to obesity, heart disease and type II diabetes.

The research team is seeking children aged 5 – 18 years from your school to participate in this study during school hours. Students will be given a database / questionnaire to be completed in advance by their parents / carers that will take you approximately 15 minutes to complete. This information will help the researchers make links between age, gender, motor skills and parents perceived level of physical activity and health status of their child. It will also establish if parents are willing for their child to participate in future research opportunities in this area with the same research team.

No findings/ information, which could identify any individual participant, will be published. Content showing age related, gender related and geographical trends for the above mentioned data only will be published. The confidentiality of your child's participation is assured by our procedure, in which the databases / questionnaires of all



CONSENT FORM
(Parent and Participant)

***Associations between waist circumference, blood pressure, motor skills,
fitness levels and BMI in Queensland children.***

BUHREC Protocol Number: RO-1019

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Dr Nancy Low Choy, Associate Professor of Physiotherapy, Bond University.

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University

The specific aims of the study are to:

1. Establish the validity of the MMT (Milne Motor Test) as a suitable test of motor ability for children aged 5 – 18 years.
2. Investigate associations between a number of health related measures in children aged 5 – 18 years from varying geographical regions of Queensland.
3. Establish early data for collation with larger studies which can be used to develop Queensland and Australian Waist Circumference percentiles.

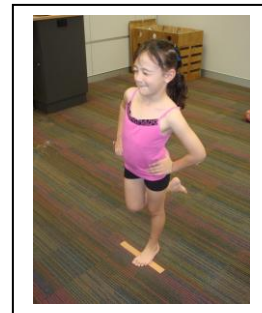
CONSENT: I, (parents name) have read and understand the attached explanatory statement and have informed my child of the details of this study and agree for my child (child's name) from (year level), (school name) to be included as a participant of this study being undertaken by staff from Bond University.

Signature: _____ Date: _____

Child's Signature: _____ Date: _____

Witness: _____ Date: _____

Appendix 9 – Recruitment Flyer (RO1019)



Would you like for your child to have the opportunity to participate in:

A study investigating associations between health related measures, motor skills and fitness levels in Queensland school aged children.

A research team from Bond University Physiotherapy Department will be visiting your school soon and is seeking children of all shapes, sizes and fitness levels to participate in this study. Should you agree for your child to participate in this study we would ask the parent or carer to complete a simple questionnaire (student database) including Age, DOB, Gender, Reported Medical History, School, Physical Activity Levels, Description of Child's Health Status & Activity Level. You would be asked to give permission for the following measures to be collected with your children:

1. BOT2 – complete test. This is an internationally recognized standardized measure of fine and gross motor proficiency used for persons aged 4 years - 21 years.
2. The Milne Motor Test – MMT (incorporating functional strength, coordination, speed and agility)
3. Sit and Reach Flexibility Test
4. Upper Limb Flexibility Test
5. Modified Shuttle Test
6. Balance tasks
7. Height
8. Weight
9. Waist circumference
10. Blood pressure (pre and post testing)



If you would like for your child to participate in this study during school hours, please contact Assistant Professor Nikki Milne on the contact details below as soon as possible. The research team will arrange a time for your child's participation and will send consent forms to you directly. Parents will be invited to attend the research session with their child if they wish.

Chief Investigator: Assistant Professor Nikki Milne (PhD student)
Bond University
Health Sciences and Medicine Faculty
Ph: 0411558447 / (07) 55954155
E-mail: nmilne@bond.edu.au

Appendix 10 – BUHREC Ethical Approval (RO1019)



**BOND
UNIVERSITY**
BRINGING AMBITION TO LIFE

**HUMAN RESEARCH
ETHICS COMMITTEE**

Bond University
Gold Coast, Queensland 4229
Australia

Ph: +61 7 5595 4194
Fax: +61 7 5595 1120
(from overseas)

Email: buhrec@bond.edu.au

ABN 88 010 694 121
CRICOS CODE 00017B

4 September 2009

A/Prof Nancy Low Choy/Nikki Milne
Faculty of Health Sciences and Medicine
Bond University

Dear Nancy and Nikki

Protocol No: RO1019
Project Title: Associations between waist circumference, blood pressure, motor skills, fitness levels and BMI in South East Queensland children

The Committee wishes to extend thanks to you for attending the Committee Meeting and for subsequently submitting the amendments as requested after a Full Review of your application.

I am pleased to advise that approval has been granted conditional upon you obtaining gatekeeper permission from Central Office, Queensland Education and each of the Principals of the Schools to be used, prior to commencement of your research. Please submit copies of these to us for our records.

It is important to remember that BUHREC's role is to monitor research projects until completion. The Committee requires, as a condition of approval, that all investigations be carried out in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Research Involving Humans and Supplementary Notes. Specifically, approval is dependent upon your compliance, as the researcher, with the requirements set out in the National Statement.

Additionally, approval is given subject to the protocol of the study being under taken as declared in your application, with amendments, where appropriate.

As you may be aware the Ethics Committee is required to annually report on the progress of research it has approved. We would greatly appreciate notification of the completed data collection process and the study completion date.

Should you have any queries or experience any problems, please liaise directly with Caroline Carstens early in your research project: Telephone: (07) 559 54194, Facsimile: (07) 559 51120, Email: buhrec@bond.edu.au.

We wish you well with your research project.

Yours sincerely

Dr Mark Bahr
Chair

www.bond.edu.au/research/ethics



Explanatory Statement

Title: *Physiotherapists and Childhood Obesity: Current trends in practice*

BUHREC Protocol Number: RO-1144

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University. (PhD; M Phty (Research); B Phty (Hons).

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University. (MPhty, MEd (ECE), BExSc, BEd, Grad Cert Clinical Ed)

Childhood obesity (a precursor for many chronic ill health conditions) poses a major public health problem throughout Australia and internationally, with 25% of Australian children currently overweight or obese (one in every five school-age child). The Australian Federal Government has recently indicated that research into, and intervention for, Childhood Obesity is a high priority area. However, there is a perceived lack of recognition of physiotherapy services for children in dealing with, and acting to prevent childhood overweight and obesity within our own profession and by the community, which is complicated by a lack of guidelines to direct clinical practices despite physiotherapists working in, or in association with, a number of Childhood Obesity Clinics around Australia.

The research team aims to complete a nationally based audit of Physiotherapy Services for children in this category which will provide a demographic profile of physiotherapy participants and services working with overweight / obese children across Australia. This will provide quantitative and qualitative information to inform our profession of the current utilisation of physiotherapy services for children who are overweight or obese, to document the perceived needs of these children as identified by these professionals, as well as inform our profession of the training and professional development needs for physiotherapists to best manage the growing caseload of children who are at high risk of developing conditions of chronic ill health without pre-emptive intervention. It will also inform our profession of the need for resource development and future research directions in this high priority area of health.

The research team is seeking Physiotherapists working with children in Australia to participate in this study by completing an electronic questionnaire which will provide a demographic profile of physiotherapy participants and services working with overweight / obese children. Specifically:

- Location and types of Physiotherapy services
- Referral sources and waiting times
- Training received / perceived requirements for professional development and clinical competencies required to work with overweight or obese children
- Involvement in health promotion / prevention of childhood obesity, development of position statements, policies or clinical guidelines.
- Awareness of and use of outcome measures by physiotherapists when working with overweight or obese children.

The questionnaire will take approximately 10 – 15 minutes to complete and will only require web access (via cut and paste) to the following link:

<https://www.surveymonkey.com/s/Physiochildobesity>

Alternatively, if you do not have access to the web, a paper- based survey can be provided for you to complete with a reply paid envelope / address to be returned to the research team at Bond University.

In completing the survey, if you indicate that you have developed or worked under a policy or clinical guidelines to direct your Physiotherapy practices with overweight or obese children, you are asked to also consider completing 'Consent form 2' – to participate in a focus group regarding the policies or guidelines you are using. For this reason it is important for the research team to match your contact details to your original survey. Once data collection is complete your personal details will be removed from the data sets.

All data will be coded and de-identified and no findings/ information, which could identify any individual participant of this study, will be published. Quantitative and qualitative information demonstrating trends in Physiotherapy practice only will be published. The confidentiality of your participation results is assured by our procedure, in which raw data of all participants will be accessed only by the research team. All raw data is protected via a password login to the survey monkey website and any processed data will remain in a locked cabinet on a password protected computer in the chief investigators office until it is destroyed.

If you agree to participate in this study you may withdraw your consent at any time. Not participating in the research will not disadvantage you in any way.

If you have any queries or would like to be informed of the collective research findings, please contact:

Nikki Milne

Signature:

Assistant Professor of Physiotherapy and Chief Investigator

Ph: (07) 5595 4155

Fax: (07) 5595 4480

E-mail: nmilne@bond.edu.au

Address: Faculty of Health Sciences and Medicine, Bond University Q 4229.

Should you have any complaints concerning the manner in which this research is conducted, please do not hesitate to contact Bond University Human Research Ethics Committee, quoting the Project Number (**RO-1144**):

The Complaints Officer
Bond University Human Research Ethics Committee
Bond University
Gold Coast, 4229.
Telephone (07) 5595 4194
Fax (07) 5595 1120
e-mail: buhrec@bond.edu.au

PLEASE NOTE: You should keep this copy of the explanatory statement for your records



CONSENT FORM 1

Project Title: Physiotherapists and Childhood Obesity: Current trends in practice

BUHREC Protocol Number: RO-1144

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University. (PhD; M Phty (Research); B Phty (Hons).

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University. (MPhty, MEd (ECE), BExSc, BEd, Grad Cert Clinical Ed)

The overall objective of this survey audit is to establish current trends in Physiotherapy practice to children who are overweight or obese. Specifically to identify:

- Location and types of Physiotherapy services for overweight or obese children
- Referral sources and waiting times for overweight or obese children
- Training received / perceived requirements for professional development and clinical competencies required to work with overweight or obese children
- Involvement in health promotion / prevention of childhood obesity, development of position statements, policies or clinical guidelines.
- Awareness of and use of outcome measures by physiotherapists when working with overweight or obese children.

CONSENT: I, (name) from (facility), (State) have read and understand the attached explanatory statement and agree to be included as a participant of this national based survey / study being undertaken by staff from Bond University.

Signature: _____ Date: _____

Witness: _____ Date: _____



CONSENT FORM 2

Project title: *Physiotherapists and Childhood Obesity: Current trends in practice*

FOCUS GROUP

BUHREC Protocol Number: RO-1144

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University. (PhD; M Phty (Research); B Phty (Hons).

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University. (MPhty, MEd (ECE), BExSc, BEd, Grad Cert Clinical Ed)

I have read the explanatory statement and I agree for the research team to contact me directly to be involved in the planned Focus group / Teleconference to discuss the development of clinical guidelines / practice policies that I or the service I work in uses to provide services to Overweight or obese children. I understand that the Focus group findings will be used to add to the qualitative data generated by the survey. I understand that the information that I provide is confidential and that no data which may identify me personally in this study will be published.

CONSENT: Name: (Please print) _____

Signature: _____

Date: _____

Witness: (Please print) _____

Signature: _____

Appendix 12 – Paper copy of survey (RO1144)



**Physiotherapists and Childhood Obesity: Current trends in practice
A Survey of Physiotherapists Working with Children**

BUHREC Protocol Number: RO-1144

Degree Course: PhD, Bond University

Principal Investigator/Supervisor: Nancy Low Choy, Associate Professor of Physiotherapy, Bond University (PhD; M Phty (Research); B Phty (Hons)).

Chief Investigator: Nikki Milne, Assistant Professor of Physiotherapy, PhD Student, Bond University (MPhty, MEd (ECE), BExSc, BEd, Grad Cert Clinical Ed)

NAME					
POSITION TITLE					
FACILITY				STATE:	
HEALTH SERVICE				Public	
				Private	
Phone Contact:			E-mail Contact:		
GENDER					
AGE	YEARS OF PHYSIOTHERAPY PRACTICE				
20 – 30 years 30 – 40 years 40 – 50 years 50 – 64 years Above 65 years	Less than 2 years 2 – 5 years 5 – 10 years 10 – 15 years More than 15 years				
FORMAL QUALIFICATIONS	Physiotherapy	Education Facility			
	Diploma		Titled	Y	N
	Bachelor Degree		Specialised	Y	N
	Masters Degree				
	Doctor of Physiotherapy				
PhD					
	Non Physiotherapy				
	Exercise Science Sports Science Education PhD Other:				

Questions:

1. Do you provide Physiotherapy services to children who are **overweight**? (Please circle)
 - Yes
 - No

2. Do you provide Physiotherapy services to children who are **obese**? (Please circle)
 - Yes
 - No

3. Do you provide health promotion or a preventative health service to children and or their families / teachers / carers, which targets prevention of obesity or increased physical activity? (Please circle)
 - Yes
 - No

4. If you answered NO to any of questions 1 – 3, please state why? (Please tick)
 - This population is not considered by our service
 - Not high enough priority
 - Not enough Physiotherapists to service this non acute need
 - No appropriate facilities / resources
 - Staff not adequately trained / skilled in this area
 - No clinical guidelines exist for this service provision
 - No evidence exists for Physiotherapy involvement with this population
 - No interest in this area of clinical practice
 - This population are serviced adequately by other allied health services such as Dietetics
 - Service covered by another Physiotherapist
 - It is not in my job description
 - Other_____

If you do not provide any services to children who are overweight or obese please go directly to question 12 and continue.

If you answered YES to any of questions 1 – 3, please continue

5. How many hours per week would you typically allocate to service provision for children who are overweight or obese (or at risk of these)?
 - Less than 2 hours
 - 2 – 5 hours
 - 5 – 10 hours
 - 10 – 20 hours
 - 20 – 40 hours

6. Do you practice in a multidisciplinary team with regards to your service provision for overweight or obese children? (Please circle)
- Yes
 - No
7. If YES, with which multidisciplinary team members do you work? (Please tick)
- Doctors
 - Nurses
 - Occupational Therapists
 - Dieticians
 - Psychologists
 - Social Workers
 - Counsellors
 - Exercise Physiologists
 - Physical Education Teachers
 - Other (please specify)_____
8. From whom do you typically receive / accept referrals to see overweight or obese children? (Please tick)
- GP's
 - Paediatricians
 - Endocrinologists
 - Orthopaedic Surgeons
 - Other Medical Specialists
 - Nurses
 - Dieticians
 - Other Allied Health
 - Schools / Day-care
 - Parents
9. What is the average estimated waiting time for children who are overweight or obese to see a Physiotherapist? (Please tick)
- Less than 2 weeks
 - 2 weeks – 1 month
 - 1 month – 2 months
 - 2 months – 6 months
 - 6 months – 12 months
 - More than 12 months
10. Which Physiotherapy services do you believe overweight or obese children (or those at risk of these) would benefit from? (Please tick)
- Direct one on one service provision – education
 - Direct one on one service provision – exercise sessions
 - Direct service provision - group education sessions,
 - Direct service provision - group exercise sessions

- Assisted goal setting
- Physiotherapy school based interventions
- Indirect service provision – education
- Indirect service provision – exercise program development
- Multidisciplinary team assessment and review
- Other (please specify)_____

11. Do you use any outcome measures or assessment tools when working with overweight or obese children? (Please tick all measures used)

- Waist Circumference
- Hip Circumference
- BMI (Body Mass Index)
- Weight
- Height
- Heart rate pre / post exercise
- 6 minute walk
- Shuttle run
- Beep test
- Fitness tests
- Motor skills assessment
- BOT2
- Strength tests
- VO₂ Max testing
- Sub-maximal testing
- Endurance tests
- GAS – Goal Attainment Scale
- Energy consumption measurements
- Please list any specific tests or outcome measures that you are aware of or have used if not listed above _____

12. Have you received any training (formal or informal) with regards to working with children who are overweight or obese? (Please circle)

- No
- Yes
- If Yes, please specify _____

13. What areas of professional development do you think would be useful in assisting you to best manage children who are overweight or obese? (Please tick)

- Education about the prevalence of this issue
- Assessment methods for overweight or obese children (including baseline

- anthropometric measurement and appropriate outcome measures)
 - How to develop referral guidelines to assist service delivery
 - Exercise prescription for children
 - Goal setting with children who are overweight or obese
 - Communication skills with families of overweight or obese children
 - How to motivate children
 - How to educate children and their families / carers
 - Health promotion skills
 - Motor skills assessment
 - Fitness testing with children
 - Nil
 - Other (please specify)_____
-
-

14. Do you, or does your service work under the provision of any guiding policies, position statements or clinical guidelines for working with children who are overweight or obese? (Please circle)

- No
 - Yes (please specify which)_____
-
-

15. Do you believe that the development of state or national clinical guidelines would assist you to best manage children who are overweight or obese? (Please circle)

- Yes
- No

16. What percentage of children in Australia would you estimate to be overweight or obese? (Please tick)

- Less than 10%
- 10 – 20%
- 20 – 30%
- 30 – 50%
- 50 – 60%
- above 60%

17. What percentage of adults in Australia would you estimate to be overweight or obese? (Please tick)

- Less than 10%
- 10 – 20%
- 20 – 30%
- 30 – 50%
- 50 – 60%

- above 60%

18. Please indicate any specific content or themes of content which you believe should be included in "Guidelines for Physiotherapists working with overweight or obese children"

THANK YOU FOR YOUR SUPPORT IN COMPLETING THIS SURVEY.

Please remember to return the signed consent form with this survey to the reply paid address below:

Bond University
Faculty of Health Sciences and Medicine
Att: Assistant Professor Nikki Milne
PHYSIOTHERAPY STUDY
Reply Paid 67293
ROBINA QLD 4226

Appendix 13 – BUHREC Ethical Approval (RO1144)



HUMAN RESEARCH
ETHICS COMMITTEE
Bond University
Gold Coast, Queensland 4229
Australia
Ph: +61 7 5595 4194
Fax: +61 7 5595 1120
(from overseas)
Email: buhrec@bond.edu.au
ABN 68 010 694 131
CRICOS CODE 00017B

15 December 2010

A/P Nancy Low Choy, Nikki Milne
Faculty of Health Sciences and Medicine
Bond University

Dear Nancy and Nikki

Project No: RO1144
Project Title: Physiotherapists and Childhood Obesity: Current Trends in Practice

I am pleased to confirm that your Project, having been reviewed under the Full Review Procedure, has been granted approval to proceed.

It is important to remember that BUHREC's role is to monitor research projects until completion. The Committee requires, as a condition of approval, that all investigations be carried out in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Research Involving Humans and Supplementary Notes. Specifically, approval is dependent upon your compliance, as the researcher, with the requirements set out in the National Statement.

Additionally, approval is given subject to the protocol of the study being undertaken as declared in your application, with amendments, where appropriate.

As you may be aware the Ethics Committee is required to annually report on the progress of research it has approved. We would greatly appreciate notification of the completed data collection process and the study completion date.

Should you have any queries or experience any problems, please liaise directly with Caroline Carstens early in your research project: Telephone: (07) 559 54194, Facsimile: (07) 559 51120, Email: buhrec@bond.edu.au.

We wish you well with your research project.

Yours sincerely

Dr Mark Bahr
Chair



EXPLANATORY STATEMENT

Project Title: The Development of the Bond University Health and Fitness Activities Program for Young Children and Teenagers.

BUHREC Protocol Number: RO1601

Degree Course: Doctor of Philosophy (PhD), Bond University

Principal Investigator/Supervisor: Roger Hughes, Professor of Health Sciences, Faculty HSM, Bond University. (PhD)

Chief Investigator 1: Nikki Milne, Assistant Professor of Physiotherapy, Faculty HSM, Bond University. (MPhty, MEd (ECE), BExSc, BEd, Grad Cert Clinical Ed)

Chief Investigator 2: Wayne Hing, Professor of Physiotherapy, Faculty HSM, Bond University. (PhD)

Chief Investigator 3: Gary Leong, Associate Professor, Mater Children's Hospital, Director – KOALA at Mater Healthy Lifestyle Program. (PhD)

Chief Investigator 4: Michael Simmonds, Assistant Professor of Exercise and Sports Science, Faculty HSM, Bond University (PhD)

Chief Investigator 5: Claire Ronaldson, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond University (BExSc)

Chief Investigator 6: Elizabeth Cooper, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond University (BExSc)

Chief Investigator 7: Dr Michael Steele Assistant Professor, Faculty HSM, Bond University (PhD; B Maths (Hons))

A collaborative research team of health based clinicians from Bond University are seeking participants aged between 5 years to 17 years to participate in a research study. We are specifically seeking children with a variety of body shapes and sizes and aim to include children who are perceived to be overweight or obese as well as those who are in the healthy weight range. This research focuses on performance-related and health-related fitness of children and adolescents and the development of a program for improving health and fitness, where participants are able to assist with the design of their program.

Before agreeing to allow your child to participate in this research study, it is important that you read the following explanation. This statement describes the purpose, procedures and benefits of the study.

Purpose of the study:

During the period of December 2012 – December 2013 we will be collecting data which will assist us to compare and evaluate the impact of an exercise program on the performance-related fitness (motor skill proficiency) and health-related fitness (strength and endurance) of children and adolescents.

What is required if I choose for my child to participate

With your written consent, your child will be asked to participate in some baseline assessments over a weekend or 2 consecutive afternoons (each session requiring approximately 4 hours). This will encompass collecting information relating to:

1. Age, gender, ethnicity, weight, height, waist circumference, neck collar measurement, sitting height, leg length, body composition, heart rate and blood pressure.
2. There will also be a gross motor aspect using the gross motor subtests of the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2), Milne Motor Test (MMT) - incorporating functional strength, coordination, speed and agility; a quick timed test that requires the child to move from standing with hands by side, to laying on their stomach with hands above head and feet together, then rolling as a log 360 degrees, standing up jumping hands and feet out and then in (2 stage star jump), Modified shuttle test-paeds - MSTP (a timed running test where the child runs 10m, picks up a small hand held bean bag, runs back and places it in a tray and repeats this as many times as he/she can in 3 minutes) and BEEP (Standardised Shuttle) Test.
3. Assessment of aerobic capacity. This uses specialised equipment external to the body to measure gas exchange in the breath during exercise and involves using a mask or a mouthpiece during graded exercise on a treadmill with maximal effort.
4. We will also be asking your child and yourself to participate in a short 15 minute interview that will assist us to develop an intervention program that best suits the needs of your child and allows us to identify barriers and facilitators to improved health. In this interview you may be asked questions about health, nutrition, screen/media time and preferences for exercise. The interview may occur in person or over the phone.

Once baseline information has been collected and if deemed appropriate your child will be offered a school or Bond University based program to assist with developing a healthier weight status for their age and gender and or to improve general fitness and this will occur initially over the first school term in 2013 with the option to extend if desired. The program will involve two weekly activity sessions lasting for one hour at your child's school or Bond University, incorporating aerobic exercise and motor skill enhancement. Your child will also be given a home program to continue during the school term if able. At the completion of the program we will ask your child to complete some of the same measures as at baseline to gain an indication of the effect that the intervention has had. If you consent to this study, you will be contacted by a member of

the research team to arrange a time for the assessment at Bond University. This session will take approximately 2 hours for each child.

Motor skill difficulties present as a major barrier to participation in childhood physical activity, and contribute to energy imbalance that is universally recognized as a cause of weight gain. We aim to understand the barriers and facilitators to participation in physical activity and to use this information to work with the children, their teachers and family to develop an effective participant-centered / school / university based intervention for improving performance and health-related fitness in children.

Your child will be given the chance to provide input into the way the program will be delivered and the activities they would prefer to do during the intervention as well as set individualized goals. Additionally children will be offered Bond University merchandise (shirts / drink bottles etc) to encourage group cohesion and positive support and the participants will be given the opportunity to create their own name for the group. At the completion of each assessment measure involving significant effort, the participants will be asked to reflect on their level of enjoyment of the activity by simply circling a visual indicator of 'likeability' on a piece of paper that will be collected at the end of the measurement sessions.

Benefits:

In this research study there may be several potential benefits for your child and / or the researchers. The potential benefits to you and your child could include:

- 1) Identifying what activities your child enjoys and an exercise program built around this that can be used even after the formal intervention period.
- 2) Feedback to you regarding the outcomes of your child's assessment with recommendations for future intervention or follow-up assessment if required.
- 3) Progression to goal setting and treatment planning with you and your child when indicated.
- 4) Enhancing motor skill proficiency.
- 5) Assisting the clinicians and researchers to evaluate / identify the need for certain interventions to be implemented on a wider scale.

Risks/Discomforts:

Potential risks involved in this study are very small, and the researchers have considered the ethical concerns of power, safety, confidentiality, consent and voluntary participation.

For the majority of the activities the program of testing and intervention will not require the children to do anything more than what many children do each day at school and on the weekend with physical activity. For aerobic capacity testing, the children will walk on a motor-driven treadmill for 4 min, after which the speed and/or grade will increase every minute through to maximal effort or until volitional fatigue. During the test, participants' pulmonary gas exchange (air they breathe), blood pressure and cardiac rate and rhythm will be monitored by trained and accredited individuals. During maximal exercise, there is an increased risk of cardiac events. However, appropriate and extensive health screening will be undertaken prior to the test, which in some case will require a GP assessment first. Additionally, during exercise testing, participants will be very closely monitored. Any changes in normal cardiac and/or pulmonary

responses to exercise will be reason for the test to be immediately terminated. There is a minor risk of delayed muscle soreness when subjects perform exercise. Delayed muscle soreness is a normal consequence to unaccustomed exercise. Peak soreness may be experienced 24-36 hours after exercise and will generally resolve within 72 hours. During the assessment period, the children will be under the constant supervision of registered health professionals who are trained to work with children in a positive and child-centered / family-centered approach to care.

Your participation is voluntary

Your consent to allow your child to participate in this study is completely voluntary and you may withdraw your consent at any time. You are free to ask questions of the research team at any point.

All results are confidential

Any data that is collected as part of this study will be de-identified and collated under a coded number system so that no data which identifies your child will be published at any time. All information will be stored and saved on a hard-drive on the Bond University database, which will be protected by a password. Only de-identified data will be analysed with collective findings reported.

Questions / further information

If you have any questions or concerns relating to this study or if you wish to enquire about participating, you may contact:

Assistant Professor Nikki Milne at Bond University on (07) 5595 4155 / 0411 558 447
nmilne@bond.edu.au

The ethical conduct of this research

This research abides by the National Statement on Ethical Conduct in Research Involving Humans. If you have any concerns with the ethical conduct of the research party, feel free to contact:

Bond University Research Human Research Ethics Committee
by phone on (07) 5595 4194 or
email buhrec@bond.edu.au

Thank you for considering our request to allow your child to participate in this study.

Signature: _____ Date: 12.10.12
Roger Hughes, Professor of Health Sciences, Faculty HSM, Bond University

Signature: _____ Date: 11/10/2012
Nikki Milne, Assistant Professor of Physiotherapy, Faculty HSM, Bond University.

Signature: _____ Date: 11/10/2012
Wayne Hing, Professor of Physiotherapy, Faculty HSM, Bond University

Signature: _____ Date: 11/10/2012
Gary Leong, Associate Professor Mater Children's Hospital, Director – KOALA at Mater
Healthy Lifestyle Program

Signature: _____ Date: 12-10-12
Michael Simmonds, Assistant Professor of Exercise and Sports Science, Faculty HSM,
Bond University

Signature: _____ Date: 12-10-12
Claire Ronaldson, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond
University

Signature: _____ Date: 12-10-12
Elizabeth Cooper, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond
University

Signature: _____ Date: 11/10/2012
Dr Michael Steele Assistant Professor, Faculty HSM, Bond University

CONSENT SHEET – Child / Parent Study Group

BUHREC Protocol Number: RO-1601

PROJECT TITLE: The Development of the Bond University Health and Fitness Activities Program for Young Children and Teenagers.

PRINCIPAL INVESTIGATORS:

Principal Investigator/Supervisor:

Roger Hughes, Professor of Health Sciences, Faculty HSM, Bond University. (PhD)

Chief Investigator 1: Nikki Milne, Assistant Professor of Physiotherapy, Faculty HSM, Bond University. (MPhty, MEd (ECE), BExSc, BEd)

Chief Investigator 2: Wayne Hing, Professor of Physiotherapy, Faculty HSM, Bond University. (PhD)

Chief Investigator 3: Gary Leong, Associate Professor, Mater Children's Hospital, Director – KOALA at Mater Healthy Lifestyle Program. (PhD)

Chief Investigator 4: Michael Simmonds, Assistant Professor of Exercise and Sports Science, Faculty HSM, Bond University (PhD)

Chief Investigator 5: Claire Ronaldson, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond University (BExSc)

Chief Investigator 6: Elizabeth Cooper, DPhty Student, Doctor of Physiotherapy Program, Faculty HSM, Bond University (BExSc)

Chief Investigator 7: Dr Michael Steele Assistant Professor, Faculty HSM, Bond University (PhD; B Maths (Hons))

By signing below, I confirm that I have read and understood the information package and in particular have noted that:

1. I have read the Explanatory Statement for this research project (RO-1601).
2. I understand what is being asked of my child and I have had all my questions about this research project answered to my full satisfaction.
3. I understand that the interview will be audio-recorded in order for the research team to be thorough and accurate with all information provided and will occur in a mutually agreed setting.
4. I understand that all information collected and audio recorded will remain confidential and that no data that may identify the school or any individual will be published.
5. I have been informed about and accept the possible risks and benefits that are expected from my child's participation in this research project.
6. I understand that the research project will be carried out as described in the Explanatory Statement, and on that basis, I agree to allow my child to participate in this research project.
7. I understand that my child's participation is voluntary and that if I choose not to allow my child to participate in this research project, I may do so, and that I can withdraw my child at any stage.
8. I understand that I can contact the Bond University Human Research Ethics Committee on 07 55954194 or email buhrec@bond.edu.au if I have any concerns about the ethical conduct of the project.

9. I understand this project will meet the National Statement on Ethical Conduct in Human Research (Privacy), at <http://www.nhmrc.gov.au/publications/synopses/e72syn.htm>

Participant Name	Signature	Date
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Parent Name	Signature	Date
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Investigator 1	Signature	Date
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COPY



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HUMAN RESEARCH
ETHICS COMMITTEE
Bond University
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Australia
Ph: +61 7 5595 4194
Fax: +61 7 5595 1120
(from overseas)
Email: buhrec@bond.edu.au
ABN 59 050 494 121
CRICOS CODE 600078

4 December 2012

Professor Roger Hughes
Faculty of Health Sciences and Medicine
Bond University

Dear Roger

Protocol No: RO 1601
Project Title: The development of the Bond University Health and
Fitness Activities Program for Young Children and Teenagers

I am pleased to confirm that your project was reviewed under the full review procedure and you have been granted approval to proceed.

As a reminder, BUHREC's role is to monitor research projects until completion. The Committee requires, as a condition of approval, that all investigations be carried out in accordance with the National Health and Medical Research Council's (NHMRC) National Statement on Ethical Conduct in Research Involving Humans and Supplementary Notes. Specifically, approval is dependent upon your compliance, as the researcher, with the requirements set out in the National Statement as well as the research protocol and listed in the Declaration which you have signed.

Please be aware that the approval is given subject to the protocol of the study being undertaken as described in your application with amendments, where appropriate. As you may be aware the Ethics Committee is required to annually report on the progress of research it has approved. We would greatly appreciate if you could advise us when you have completed data collection and when the study is completed.

Should you have any queries or experience any problems, please contact early in your research project: Telephone: (07) 559 53554, Facsimile: (07) 559 51120, Email: buhrec@bond.edu.au.

We wish you well with your research project.

Yours sincerely

Dr Mark Bahr
Chair